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This is an interdisciplinary conference. Topics include .fundamentals of laser-matter interactions, quantum and atomic optics, ultrafast phenomena, nonlinear optical phenomena, new NLO materials and physics of low-dimensional systems, basc concepts of laser chemistry, biophysics, and biomedicine, and new frontiers in optical information technologies

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SESSIONS:

MA - Opening. Plenary Lectures I

Opening. Plenary Lectures I

Presider: *N.I. Koroteev, M.V.Lomonosov Moscow State University, Russia*

15:30-16:15 **CONFERENCE HALL**
MA (Plenary Lecture) - Nonlinear optics with single atoms and photons: The quantum frontier
H.J. Kimble, California Inst. Of Technology, USA.

MA1 Nonlinear Optics with Single Atoms and Photons: The Quantum Frontier

H. J. Kimble
Norman Bridge Laboratory of Physics 12-33
California Institute of Technology, Pasadena, CA 91125

Modern research in the area of *cavity quantum electrodynamics* explores quantum dynamical processes for single atoms strongly coupled to the field of a high quality factor resonator in a setting for which individual photons can play a decisive role. [1] The particular objectives of the research programs in the Quantum Optics Group at Caltech [2] include an investigation of the utilization of the atom-cavity system for the implementation of quantum logic, [3] as well as for studies of quantum state synthesis [4] and the realization of quantum communication networks. [5] In qualitative terms, we are attempting to explore nonlinear optics in a new domain for which the quantum character of the atom-field interaction emerges as dominant.

The scientific and technical challenges implicit in reaching these goals are daunting. For example, by marrying the techniques of laser cooling and trapping with those of cavity QED, we are attempting to isolate an atom within a high finesse optical cavity, [6,7] with atomic motion tracked in real time at a level near the standard quantum limit. By following the lead of Professor V. Braginsky and colleagues at Moscow State University, we are pursuing the development of a new generation of optical resonators for cavity QED which exploit the whispering gallery modes of quartz microspheres with record cavity finesse. [8] On a theoretical front, we are investigating quantization of atomic center-of-mass motion within the setting of cavity QED, [9] as well as the implementation of quantum feedback control. In general terms, our research seeks to exploit the atom-cavity system as a paradigm for the investigation of quantum dynamical processes for open quantum systems in a regime of strong coupling.

This work is supported by the National Science Foundation, by DARPA via the QUIC Institute which is administered by ARO, and by the Office of Naval Research.

[1] For a review, see *Cavity Quantum Electrodynamics*, ed. P. Berman (Academic Press, San Diego, 1994).
[2] For a more detailed discussion, see H. J. Kimble, *Highlights in Quantum Optics*, in Phil. Trans. R. Soc. Lond. A355, 2327 (1997).
[3] Q. A. Turchette, C. J. Hood, W. Lange, H. Mabuchi, and H. J. Kimble, Phys. Rev. Lett. 75, 4710(1995).
[4] C. K. Law and H. J. Kimble, J. Mod. Optics 44, 2067 (1997).
[5] J.-I. Cirac, P. Zoller, H. J. Kimble, and H. Mabuchi, Phys. Rev. Lett. 78, 3221 (1997); S. J. Van Enk, J.-I. Cirac and P. Zoller, Phys. Rev. Lett. 78, 4293 (1997).
[6] H. Mabuchi, Q. A. Turchette, M. S. Chapman, and H. J. Kimble, Opt. Lett. 21, 1393 (1996).
[7] C. J. Hood, T. Lynn, M. Chapman, and H. J. Kimble, submitted to Phys. Rev. Lett. (1997).
[8] D. W. Vernooy, V. S. Ilchenko, H. Mabuchi, E. Streed, and H. J. Kimble, Opt. Lett. 23, 247 (1998).
[9] D. W. Vernooy and H. J. Kimble, Phys. Rev. A56, 4287 (1997).

16:15-17:00 **CONFERENCE HALL**
MA (Plenary Lecture) - Ultrahigh resolution laser spectroscopy with cold atoms and molecules
S.N. Bagayev, Inst. Of Laser Physics, SB RAS, Russia.

MA2

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T U E S D A Y

30 June 1998

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TuA - Fundamental Aspects of Laser-Matter Interaction I
TuB - Ultrafast Phenomena I
TuC - Quantum and Atomic Optics I
TuD - Nonlinear Optical Phenomena I
TuE- Fundamental Aspects of Laser-Matter Interaction II
TuF- Ultrafast Phenomena II
TuG- Quantum and Atomic Optics II
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8:30-10:45 **RED HALL**

TuA - Fundamental Aspects of Laser-Matter Interaction I

Presider: *A.M. Bonch-Bruevich, Vavilov State Optical Inst., Russia*

8:30
TuA1
(Keynote)

LIGHT INDUCED MULTIPOLAR SYMMETRY PATTERNS IN MOLECULAR NONLINEAR OPTICS: FROM MOLECULAR TO PHOTONIC ENGINEERING

Joseph ZYSS*,** and Sophie BRASSELET**
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Throughout two decades of research in the now well identified domain of *Molecular Nonlinear Optics*[1], one can recognize three successive steps corresponding to increased levels of control of molecular organization processes via externally driven physical parameters, the last one at the focus of our current research activity:

- Firstly, *molecular crystals* helped set-up, in conjunction with molecular response studies in solution, the central template of a polar donor-acceptor conjugated system. However, the complexity of internal forces governing the structure of crystals hampered the predictive potential of this *molecular engineering* approach whereas difficulties in developping crystal growth technologies, although by no means final, were eventually met.

- Subsequent development of *electrically poled polymers* embedding polar nonlinear molecules provided the major asset of a fully predictive technologically viable orientational process as governed by an externally driven Langevin type dipole-field coupling potential. Significant demonstrations followed, particularly in the field of integrated optics and high bandwidth waveguiding electrooptic modulators. However, the relatively crude translationally invariant vectorial pattern associated to a capacitor-like poling geometry is a bottleneck towards spatially modulated structures, such as required for quasi-phase-matching or photonic band gap materials.

- The third step is rooted in early propositions by R.J.Glauber and Baranova et al.[2] of resonnantly interfering one- and two-photon absorption processes capable of breaking-up centrosymmetry,while the experimental observation of frequency doubling in silica fiber in the mid eighties, recently extended to molecular media[3], fully triggered the field. This effect can be rationalized in terms of $\langle E^3 \rangle \neq 0$ related processes whereby the non vanishing time-averaged cube of a coherent combination of laser fields is interacting with matter. In parallel, the dipolar charge transfer concept has been embedded in the broader family of three-dimensional multipolar systems[4] whereby multiple charge transfer configurations can be assessed by polarized harmonic light scattering in solution with a three level quantum framework to account for their optical dispersion[5]. The two domains merged when light induced transient and permanent orientations of multipolar systems, including octupolar (e.g. dipolarless) species, could indeed be achieved with considerable advantages over the previous electric field approach[6-8]. A spatial tensorial distribution of the optical properties (linear, quadratic or cubic) can be patterned and controlled by interfering three beams at matching frequencies ($\omega_1+\omega_2=\omega_3$) with tensorial properties governed by their polarization states. Ellipsometric control of the optical tensor can lead to refined nonlinear patterns *whereby the multipolar symmetry of the* $\langle E^{\omega_1} \otimes E^{\omega_2} \otimes E^{\omega_3} \rangle$ *write field tensor is transfered to* the irradiated medium via orignal field-molecule multipolar coupling schemes[8].

1- *Molecular Nonlinear Optics* , J.Zyss Ed. (Academic Press, New-York,1994)
2- N.B.Baranova and B.Ya.Zeld'ovitch, J.Opt.Soc.Am.B8,27(1991) *and references therein*
3- C.Fiorini, F.Charra, J.M.Nunzi, J.Opt.Soc.Am.B 11,2347(1994)
4- J.Zyss, J.Chem.Phys. 98,6583(1993)
5- S.Brasselet and J.Zyss, J. Nonlinear Phys.Mat. 5,671(1996)
6- C.Fiorini, F.Charra, J.M.Nunzi, I.Samuel and J.Zyss, Opt.Lett. 20, 2469(1995)
7- S.Brasselet and J.Zyss, Opt.Lett. 22(19),1464(1997)
8- S.Brasselet and J.Zyss, J.Opt.Soc.Am.B 15(1),257(1998)

9:15
TuA2
(Invited)

From Optical Parametric Oscillators to Optical Frequency Synthesizers

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Until very recently, c.w. OPOs operated above threshold were rarely used in application, although their potential has been recognized since the early days of nonlinear optics. Through a series of technological and nonlinear materials developments this situation has completely changed. C.w. OPOs can now be *designed* and operated with excellent specifications and are opening up applications of practical relevance [1].

The important developments have been in the field of pump lasers, nonlinear crystals, coatings, OPO cavity design, active stabilization of OPO parameters and optimization for maximum coversion efficiency. Powerful (1W) single-frequency and narrow linewidth *diode-pumped Nd:YAG lasers are* commercially available. Periodically-poled crystals exhibit high nonlinearity and this facilitates operation of singly-resonant OPOs (SRO) [2]. Grating lengths can be custom designed for emission at desired wavelengths. Multigrating crystals permit easy tuning of OPO emission over huge ranges [3]. Large bandwidth, low-loss dielectric coating can be deposited on these crystals and are reliable. Concerning the OPO designs, various implementations have been tested and their characteristics explored.

One central aspect for reliable (i.e. mode-hop-free) OPO operation has been the use of active control of either pump frequency or OPO cavity length in order to compensate for fluctuations of these two parameters and of crystal temperature. Only recently operation of both doubly-resonant (DRO) and SROs without mode-hops for essentially unlimited time was achieved [4,5]. This was made possible by *use of the monolithic Nd:YAG pump laser*, whose frequency and power stability are advanageous, and active OPO cavity length control. An important consequence is the high level of power stability and of absolute frequency stability of both signal and idler waves (within 30 MHz over 1 hour) and their narrow linewidth (<100 kHz), again for both DROs and SROs. Smooth frequency tuning of signal and idler is done by by pump frequency tuning and ranges of 4.5 and 9.4 GHz, respectively, are *obtained*. With regard to obtaining a large emission range, the signal-resonant SRO is advantageous since it requires a HR coating over a smaller relative bandwidth than the total (signal plus idler) relative emission bandwidth. The range between 1.45 and 4.0 μm has thereby been covered with a single multigrating device [5] with a natural gap near degeneracy between 2.0 and 2.3 μm. Maximum output power on the idler was 230 mW at 34% conversion efficiency.

First applications of practical relevance have been demonstrated with this SRO, molecular *spectroscopy* and photoacoustic trace gas detection. We demonstrated a sensitivity of 0.5 ppb for ethane detection, comparable to the CO overtone laser [6].

For high-resolution spectroscopy applications we are also pursuing the absolute frequency stabilization of OPO to references. Sub-kHz absolute frequency stability was reached with a DRO at 1082 nm frequency-locked to a cryogenic optical resonator [4]. *This combination of techniques open up* novel possibilities in frequency metrology and atomic and molecular physics experiments.

State of the art c.w. OPOs, when used in conjunction with frequency measurement devices (wavemeter, molecular markers, etc.), may be considered to be close to an optical synthesizer, a reliable source of laser radiation of high spectral purity capable of emitting any optical frequency.

[1] see e.g. Special issue on OPOs, Appl. Phys. B, May 1998.
[2] M. Yamada et al., Appl. Phys. Lett. 62 , 435 (1993); J.Webjörn et al., Electron. Lett. 30, 894 (1994)
[3] L.E. Myers et al., J. Opt. Soc. Am. B 12, 2102 (1995)
[4] R. Al-Tahtamouni et al., Appl. Phys. B, submitted (1998)
[5] K. Schneider et al., Opt. Lett. 22, 1293 1997)
[6] F. Kühnemann et al., Appl. Phys. B, submitted (1998)

9:45
TuA3
(Invited)

High intensity coherent super-continuum radiation from optical channeling

Hajime Nishioka, and Ken-ichi Ueda

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In the Institute for Laser Science (ILS), a super-broad-band coherent light source is ready for ultra-fast optical study in entire light-wavelength regions. The new light source provides intense vacuum-ultra-violet to infrared spectra (from 150 nm to several micron), an ultra-short pulse duration, tera watt light power, and a small focusing spot.

The broad spectrum is produced by both spatial and temporal phase modulation due to nonlinear refractive index in rare gas media, which is induced by an intense and ultra-short laser pulse itself. A 2 tera watt laser pulse from a table-top titanium sapphire laser system induces significant change of the refractive index, in where phase velocity of light is dominated by the laser intensity. In space, an intense laser beam focus itself toward high intensity regions, then it creates a fine self-trapping channel. The self-trapping channel having a diameter of 100 micron guides an intense femtosecond laser pulse for a distance of several tens of meters, like as an optical fiber. Because the diameter of the self-trapping channels changes as a function of instantaneous light intensity, ultra-fast and deep light intensity modulation (up to 10^{14} W/cm^2) is produced in the channel. The high intensity and long interaction length conditions efficiently produce self- and cross-phase modulations. The efficient 4-WM spectral broadening and short pulse duration were produced because the group velocity dispersion in the atmospheric pressure rare gas media is small enough. More than 70 % of the pump energy spread out to the side-bands. The pulse duration of the trapped white pulse was measured to be 150-200 fs with a group delay of 1fs/nm. The spectral intensity of the white laser source exceeds 1 GW/nm in entire UV to IR regions.

Ref. H. Nishioka, M. Odajima, K. Ueda, and H. Takuma: Opt.Lett.vol.20,pp.2505(1995).

10:15
TuA4
(Invited)

Physical Mechanisms of Short Pulse Laser Ablation

D. von der Linde

Institut f. Laser- u. Plasmaphysik, Universität Essen, D-45117 Essen, Germany

Laser ablation is a process of great interest for a number of technological applications. Recent experimental work has indicated that the use of pico- or femtosecond laser pulses may offer advantages over pulses of longer duration. We have studied ablation of metals and semiconductors by ultrashort laser pulses using time-resolved optical microscopy. This technique permits recording of the changes of the surface morphology during the entire chain of processes from the deposition of the laser energy to the final surface structure. The data show that for energies close to the ablation threshold removal of material is brought about by relatively slow thermo-physical processes. After the thermalization of the laser energy which takes about a picoseond the surface is covered by a thin layer of hot material under high pressure. Subsequent rapid hydrodynamic expansion and cooling transforms the metallic fluid into a liquid-vapor mixture which becomes optically transparent. Because the sound velocity of the heterogenopus phase is extremely low, the front of expanding material forms an sharp interface which gives rise to optical interference [1]. We observe high contrast Newton ring interference patterns from which the thickness and the velocity of the ablating layer can be obtained. Such interference phenomena have been observed in a wide variety of materials suggesting that this type of ablation mechanism is of general nature.

[1] D. von der Linde, K. Sokolowski-Tinten, J. Bialkowski, Appl. Surf. Sci. **109/110**, 1 (1997).

8:30-10:45 **GREEN HALL**
TuB - Ultrafast Phenomena I
Presider: *C.L. Tang, Cornell Univ., USA*

8:30
TuB1
(Keynote)

FIBER DEVICES FOR ULTRAHIGH-SPEED PHOTONICS

Erich P. Ippen
Department of Electrical Engineering and Computer Science
Department of Physics
Research Laboratory of Electronics
Massachusetts Institute of Technology
Cambridge, MA 02139

Soliton fiber ring lasers are attractive diode-pumped sources of picosecond pulses with picojoule energies. With passive modelocking, solitons as short as 400 fs are generated at fundamental, round-trip, repetition rates of about 50 MHz with per-pulse energies of 10 pJ. Pulse initiation and stabilization is produced by nonlinear polarization rotation; steady-state characteristics are defined, and limited, by soliton effects. These lasers are inherently low-noise and the pulse timing jitter has been measured to be close to the quantum limit. With an active modulator, driven at a harmonic of the round-trip time to establish multiple time slots in the ring, output pulse trains can be produced at much higher (>10 GHz) repetition rates. In actively stabilized systems, also, soliton effects and the boundaries of pulse stability can be studied in the absence of nonlinear polarization rotation. The soliton effects, in conjunction with filtering, quantize individual pulse energies and make it possible to store pulse patterns for long periods of time. Such a ring, therefore, can be used for storing high-bit-rate packets with kilobits of data. The dynamics of loading and unloading such packets are under investigation.

By alternating dispersion, positive and negative, it is possible to circumvent the soliton-imposed limitations of the modelocked fiber ring laser. Such a system, dubbed the stretched-pulse fiber laser, has been shown to produce pulses shorter than 100 fs with energies of 2 nJ. A stretched-pulse laser has less net roundtrip dispersion than the soliton ring and can exhibit even lower pulse-to-pulse jitter than the soliton laser. Its high peak output powers enable efficient conversion to the second harmonic at 780 nm, a suitable wavelength for femtosecond Ti:sapphire amplification. The broad spectral output at the fundamental wavelength can also be divided to yield pulses at multiple wavelengths simultaneously for WDM fiber network applications.

For shaping and controlling ultrashort pulses after generation, a variety of nonlinear optical devices and filters have been developed. Among these, a new dispersion-imbalanced nonlinear optical loop mirror provides unique nonlinear filtering. This device is constructed with different dispersion fiber in the two halves of the loop. For cw light it is perfectly balanced and therefore completely reflective. On the other hand, pulses traveling in the two different directions undergo spreading and accumulate nonlinear phase shifts differently. Thus, the loop only effectively transmits and reshapes pulses of a specific intensity and duration. Experiments have demonstrated strong rejection discrimination between pulses and various types of background.

9:15
TuB2
(Invited)

Quantum Coherent Effects in Semiconductor Spectroscopy studied with a Two-Color Femtosecond Ti:Sapphire Laser

C. Fürst, A. Leitenstorfer and A. Laubereau
Physik Department E 11, Technische Universität München
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We present experiments revealing, for the first time, coherent features in the dynamics of free carriers in semiconductors. The measurements are carried out in different regimes of carrier densities, where either LO phonon scattering or carrier-carrier scattering predominates. In the past, most of the experiments investigating such scattering processes have been explained within the semiclassical Boltzmann equation. In this framework, energy and momentum conservation holds for every single collision. In our experiments at very low carrier densities we clearly show, that this picture breakes down for ultrashort timescales and intraband quantum coherence effects show up [1]. Using synchronized pulses of different bandwidths from our two-color femtosecond Ti:sapphire laser, we study the evolution of strongly nonthermal electron distributions at extremely low electron densities of 8×10^{14} in GaAs. Initially, the phonon replica are substantially broadened, clearly demonstrating that energy does not have to be conserved in the scattering events on timescales in the order of one LO phonon oscillation period. As time proceeds, quantum interference becomes operative resulting in a narrowing of the maxima into the shape excited in the semiclassical limit. Results of an analytical model treating the memory effects exactly will be presented. Our analysis shows, that memory effects come into play whenever transition rates are of the same order of magnitude or even faster than the inverse frequency of the energy quanta involved.

The coherent features of the optical response completely change for high intensity excitation at carrier densities above $10^{18}\mathrm{cm}^{-3}$. For the first time, our two-color experiments demonstrate Rabi oscillations in the absorption continuum of a semiconductor. Up to two Rabi cycles are observed in bulk InP for peak intensities exceeding $4\,\mathrm{GW/cm^2}$. Extremely fast dephasing due to carrier-carrier scattering leads to a strong damping of the oscillations. The measurements show that the dephasing rate decreases with time. We attribute this finding to a hindering of carrier- carrier scattering due to the quantum kinetic build-up of the screening and an increasing influence of Pauli blocking.

[1] C.Fürst, A.Leitenstorfer, A.Laubereau, R.Zimmermann, Phys.Rev.Lett. 78 3733 (1997)

9:45
TuB3
(Invited)

Paper is not available

10:15
TuB4
(Invited)

Paper is not available

8:30-10:45 **BEIGE HALL**

TuC - Quantum and Atomic Optics I

Presider: *J.H. Kimble, California Inst. Of Technology, USA*

8:30
TuC1
(Keynote)

Quantum Phenomena in the Radiation Interaction of Single Atoms

Herbert Walther

Sektion Physik der Universität München and
Max-Planck-Institut für Quantenoptik
85748 Garching, Germany

Summary:
In recent years quite a few experiments on the interaction of radiation with single atoms in cavities and traps have been performed emphasising the quantum features of the interaction. A brief review of recent experiments of this type will be given. Since traps allow to probe the same atom for a long time and in addition to study the detailed time behaviour of the radiation-atom interaction e.g. by observing quantum jumps, it is promising to combine optical cavities with high quality factors with the known trapping techniques. It is shown that a single atom laser with interesting new features can be realised. Furthermore cavity-modified quantum jumps can be investigated. Another feature of the new setup is that ultracold atoms can be studied so that the influence of the atomic de Brogie wavelength on the interaction with an optical wave gets observable. New phenomena are expected when both the de Broglie wavelength and the optical wavelength reach the same order of magnitude.

9:15
TuC2
(Invited)

Single Atom Dynamics in a Magnetooptical Trap

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The only non invasive probe available for stored neutral atoms is its resonance fluorescence. Information on internal and external dynamical processes of the atom is encoded in the fluctuations of the scattered light field. We have therefore measured the intensity correlation function $g_{ij}^{(2)}(\tau) = \langle I_i(t) I_j(t+\tau)\rangle / \langle I_i\rangle\langle I_j\rangle$ of a single or a few distinguishable atoms stored in a magnetooptical trap. Cesium atoms are stored in a standard sixbeam magnetooptical trap with strong magnetic field gradients of $\approx 400G/cm$ and a typical storage time of a few minutes. At the single atom detection rate of 10^4 photons/s our measurement is essentially shot noise limited. Our measurement consists of a record of photon arrival times with ns resolution and up to several hours. The data record is subsequently correlated on a computer.

With this method we observe correlations on all relevant time scales: Within the 30 ns life time of the Cesium atom excited state antibunching and Rabi oscillations are observed without need for any corrections. A two level atom model is surprisingly sufficient to reproduce the observation within a few percent. Furthermore we have monitored polarization cross correlations. While no correlation signal is observed for crossed linear polarizations ($g_{\sigma\pi}^{(2)}(\tau) = 1$), strong contrast is obtained for circular polarizations, $g_{\sigma^+\sigma^+}^{(2)}(0) = 2$ and $g_{\sigma^+\sigma^-}^{(2)}(0) = 0.5$, indicating strong optical pumping due polarization gradients of the interfering trapping light fields at time scale of approximately 1 μs. By aperturing part of the trapping volume we have been able to record position correlations, finding good agreement with a Fokker-Planck model of atomic motion in the MOT at temperatures near the Doppler limit. Finally we have also analyzed the dynamics of the trapped atom number. Atomic capture events from the background gas are completely random. Departure of atoms from the trap, however, is strongly influenced by the number of atoms in the trap due to the light-induced binary collision between cold atoms. By analysing the trap-loss rates for different small numbers of trapped atoms we have been able to destinguish between two types of cold collisions: collisions causing double-atom losses and 'soft' ones resulting into departure of a single atom only.

Our results show that by combining photon correlation measurements with single atom trapping complete information on dynamical behaviour of laser-cooled atoms may be obtained.

9:45
TuC3
(Invited)

ATOM INTERFEROMETRY AND HIGH RESOLUTION SPECTROSCOPY OF MG BEAMS

S.N. Bagayev, V.I. Baraylia , A.E. Bonert, A.N. Goncharov
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Mg atoms open possibility to build up an atom-optical interferometer[1-3] with special separation of its arms. Life time of upper level of the intercombination transition $^1S_0$ -> $^3P_1$ equal to 5 ms allow to obtain special separation up to 0.2 mm. To realize an atom-optical interferometer with magnesium atoms and to detect interferometric fringes with highest resolution one have to build up a laser source at 457 nm with linewidth <10 Hz and with long term frequency stability better than $\Delta v/v = 10^{-14}$. We discuss the possibility of an external magnesium cell and saturation resonance at $^1S_0$ -> $^3P_1$ transition for long term frequency stabilization of Ti:Al_2O_3/LBO laser system at 457 nm. Spatial separation of matter wave packets in interferometer arms will be possible with Mg24 atoms cooled down 10 m/s. The laser system at 285 nm based on ring R6G cw dye laser with internal BBO nonlinear crystal has been developed for laser cooling of an atomic beam. The results of high resolution spectroscopy of magnesium beam at 285 nm [illegible]57 nm are presented. The isotopic structure of Mg transitions $^1S_0$ -> $^3P_1$ and $^1S_0$ -> $^1P_1$ have been resolved as well as the hfs of Mg25 transition $^1S_0$ -> $^3P_1$. We also present the results of numerical simulation experiment of a broad band cooling of Mg beam.

This work was done under grant 96-02-05854-a from Russian Fund for Basic Research and with support from All-Russian scientific program «Fundamental metrology».

References

1. V.P. Chebotayev et al, J. Opt. Soc. Am. B 2, 1791(1985)
2. Ch. J. Borde', Phys. Lett. A140, 10(1989)
3. K. Sengstock et al, Appl. Phys. B 59, 99(1994)

10:15
TuC4
(Invited)

Atomic Interference in Pulsed Standing Wave Fields

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and
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Recent experimental and theoretical results of our group related to time-domain spectroscopy of trapped atoms are reviewed. Rubidium atoms that have been trapped in a MOT are subjected to one or more pairs of pulsed optical fields. The fields create or modify a spatially modulated distribution of ground state population or ground state magnetic coherence. By a proper choice of atom-field detunings and field polarizations, it is possible for the fields to act as either amplitude or phase gratings. Given the fact that modulation is created in the ground state, transient effects can persist on a time scale limited only by the time the atoms spend in the interaction region. Two types of coherent transients are considered.

In free induction decay (FID) a pulse consisting of fields having wave vectors $\mathbf{k}_1$ and $\mathbf{k}_2$ is incident on the atoms in the trap. At a time t following this pulse a readout pulse in the $\mathbf{k}_2$ direction is applied and the signal scattered in the $\mathbf{k}_1$ direction is recorded. The FID signal (and the atomic grating created by the pulse) decays on a time scale that is of order $1/|\mathbf{k}_1 - \mathbf{k}_2| u$, where u is the typical atomic speed. To increase the time scale of the experiment, one can apply a second pulse at a time T following the first pulse. The two-pulse sequence is analogous to that of a photon echo experiment and a rephasing of the atomic gratings can occur at various times following the second pulse. A readout pulse is needed to monitor the atomic grating as a function of time. Experimental results for the echo signals at $t = 2T$ and $t = 3T$ will be presented.

Both the FID and echo experiments can be carried out for a variety of field polarizations and time scales. For some field polarizations, a spatially modulated ground state magnetic coherence is created that can lead to both FID and echo signals. These signals can be created for time scales that are small compared with the inverse recoil frequency $(\omega_\kappa)^{-1} = (\hbar\kappa^2/2m)^{-1}$ (m is the atomic mass) associated with an absorption-emission process. A case of particular interest occurs when the two fields making up the pulse have the same polarization (relative to a common laboratory basis) and the atoms are subjected to an off resonant standing wave pulse. This pulse can be modeled by a periodic mechanical potential, which imposes a phase modulation on the atomic center-of-mass wavefunction (the pulse acts as a phase grating). At time scales greater than, or of the order $\omega_\kappa)^{-1}$, recoil effects transform this atomic phase grating into an amplitude grating, which can then scatter the readout pulse.

In the case of recoil-induced gratings, the echo signal as a function of the time between pulses, shows modulation at the recoil frequency and can be used to measure this frequency. A comparison of the experimental results with theoretical predictions will be given.

Methods for extending these techniques to produce atomic lattices having periods which are a fraction of an optical wavelength will be discussed, as will applications to nanolithography. Generalization of the results to two-dimensional scattering of the atoms and the Bragg scattering regime is envisioned.

8:30-10:45 **BLUE HALL**

TuD - Nonlinear Optical Phenomena I

Presider: *P.A. Apanasevich, Stepanov Inst. Of Physics, Belarus*

8:30
TuD1
(Keynote)

Femtosecond Spectroscopy on Simple Molecular Systems: Pump-Probe and Four-Wave Mixing Techniques

W. Kiefer, T. Chen, V. Engel, M. Heid, G. Knopp, A. Materny, S. Meyer, R. Pausch, M. Schmitt, and H. Schwoerer

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The wavepacket dynamics on different potential surfaces can be directly monitored using spectroscopical methods on the femtosecond time domain. As an example for the application of the fs *pump-probe* technique with detection of laser induced fluorescence (LIF) we report recent fs pump-probe studies of the influence of rare-gas collisions on coherent wavepacket motion in NaI in the gas-to-liquid region. The experiments were performed at a temperature of 670° C in a high-pressure cell *allowing for rare-gas pressures* ranging from 0 to 3 kbar. Due to an avoided crossing of the ionic ground state and the covalent excited state of NaI, a quasi-bounded adiabatic potential is formed. The pump-probe experiment yields the wavepacket dynamics for both the transition state and the product resulting from the curve crossing probability. Even at low rare-gas pressures a considerable influence of collisions on the wavepacket motion within the adiabatic potential well is found. Femtosecond pump-probe experiments were also performed on vibronically and rotationally cold clusters like the potassium dimer generated in a supersonic *beam expansion. To investigate the* vibrational dynamics of electronically excited states a first laser pulse generates a wavepacket consisting of 3-5 vibrational states. The evolution of the wavepacket in real time is monitored by a variably delayed probe pulse which excites the system to the ionic ground state. Since the transition probability depends on the localization and *position of the wavepacket the number of ions versus time delay* indicates the wavepacket evolution. The ions are detected by means of time of flight mass spectrometry to select the desired species from the molecular beam. Dependencies of transition dipole moments on the internuclear separation can be measured by carefully investigating the ionization process [3]. With two synchronous laser pulses with different wavelengths a vibrational wavepacket in the electronic ground state can be created via a stimulated Raman process. Its coherent evolution can be interrogated with the same variably time delayed ionization step [4] Femtosecond time-resolved coherent four-wave mixing (FWM) techniques [1,2] not only offer an alternative to the classical pump-probe technique but due to their many degrees of freedom frequency, timing, and polarization they are capable of revealing additional information on the quantum system. As an example we show results obtained for iodine in the gaseous phase. We could demonstrate that with these methods one can observe the dynamics of a wavepacket either evolving on the ground or on the excited state potential energy surface. For the three laser pulses interacting with the molecular system, a three-dimensional forward geometry (folded BOXCARS arrangement) was chosen. *In all experiments two laser pulses are coincident in time* ($t=3D_0$) while the third pulse arrives with a variable time delay D_t. Depending on the relative timing of the three pulses, different dynamics in the molecules are probed by one or two photon interaction resulting in the coherent four-wave mixing signal.

1. M. Schmitt, G. Knopp, A. Materny, and W. Kiefer, Chem. Phys. Lett. 270, 9 (1997). 2. M. Schmitt, G. Knopp, A. Materny, and W. Kiefer, Chem. Phys. Lett., 280, 393 (1997).
3. H. Schwoerer, P. Pausch, M. Heid, V. Engel and W. Kiefer, J. Chem. Phys. 107, 9749 (1997).
4. H.Schwoerer, P. Pausch, M. Heid, and W. Kiefer, Chem. Phys. Lett. , in press.

9:15
TuD2
(Invited)

Raman Fiber Lasers and Amplifiers

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Summary.

Recently resonantly cascaded Raman laser and amplifier were developed for amplification in optical fiber communication systems operating at the wavelength of 1.31 um [1].

The recent advent of high power (up to 10 Watts) CW cladding pumped Nd or Yb fiber lasers has promoted interest in high-power pump sources for telecommunications. It has been found that it is possible to efficiently convert the radiation from these high-power CW lasers to the radiation of longer wavelengths using stimulated Raman scatteriing in germanosilicate fibers and high- reflecting Bragg gratings, written directly in the fiber. In this case, each intermediate Raman Stokes order can be resonated and therefore efficiently converted to the next higher Stokes order until the cascade is terminated by output coupling at the desired order. So it was possible to obtain high-output powers at 1.48 µm which can be used to pump high-power and remotely-pumped erbium amplifiers [2].

High Δn germanosilicate fibers were used as the Raman gain medium in these experiments. The Raman frequency shift of germanosilicate fibers is about 430 cm^{-1}, so 1.48 µm radiation corresponds to the sixth Stokes order. In this case one needs to write in the fiber six pairs of Bragg gratings and the structure of 1.48 µm Raman fiber laser is too complicated. The best option would be a fiber with a large enough Stokes frequency shift to obtain the longer wavelength radiation corresponding to Stokes lines of low order. In addition, the fiber should be sufficiently photosensitive to obtain Bragg gratings written directly in it.

It results that a phosphosilicate fiber satisfies these requirements. The Raman spectrum of a phosphosilicate fiber shows a strong line shifted by 1330 cm^{-1}.

Using a phosphosilicate fiber as a Raman gain medium and a Nd laser as a pump simple and efficient 1.24-and 1.48 µm Raman fiber lasers have been developed [3].

References.

1. S.G.Grubb et al, Proc.Optical Amplifiers and their Applications, paper PD-3, Breckenridge, CO. (1994).
2. S.G.Grubb et al, Proc.Optical Amplifiers and their Applications, paper Sa A4, Davos, (1995).
3. E.M.Dianov et al, Electron. Letters, v.33, pp. 1542-1544, 1997.

9:45
TuD3
(Invited)

Intracavity picosecond optical parametric oscillator with kHz repetition frequency

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The generation of powerful and tunable radiation sources in the IR achievable from optical parametric processes pumped with picosecond lasers has experienced considerable interest. However, the short pulse durations cause difficulties in realizing optical parametric oscillators (OPO's) compared to typical nansosecond pulse OPO's. The oscillating fields of the signal and idler wave have to build up within the temporal time window of the pump pulse. For the picosecond long pulses this would require a cavity length of a few millimeters not suitable since the gain length is too short. That is why new approaches were established utilizing the nonlinear optical conversion, such as synchronous pumping of an OPO when MHz repetition rate pump sources are used or a travelling wave OPG which is used in a single pass.

Here we discuss a parametric conversion of high power picosecond pulses with low repetition rates, produced in a regenerative amplifier, so far been applied only in OPG's and generation and amplification schemes (OPG/ OPA). According to the low repetition frequency of up to 5 kHz, synchronous pumping of an OPO is not possible. However, synchronously pumped OPO's exhibit desirable features like good beam profiles, a small frequency bandwidth and a lower pump density in the nonlinear crystal which reduces the possibility of crystal damage compared to OPG's or OPG/OPA systems.

A combination of the resonator properties of OPO's with the available single pulse energies from regenerative amplifiers (RA) resulted in a new design of an *intracavity* OPO [1] where the nonlinear crystal is placed inside the resonator of the RA. The pump source is a previously described diode-pumped regenerative Nd:YAG amplifier [2]. For realizing a KTP-based intracavity OPO for high pulse energies a pump pulse is trapped inside the RA cavity and is amplified each time it passes through the Nd:YAG rod. On each round trip the pump pulse passes also through the 16 mm long KTP crystal and generates and amplifies the signal pulse inside an attached signal cavity, resonant for the signal wave only. The main difference of this configuration to synchronously pumped OPO is that the pump pulse energy varies each round trip. At the maximum signal pulse energy achieved after approximately 30 round trips a Pockels cell inserted inside the signal cavity is switched to produce a quarter wave retardation for ejecting the signal pulse at a polarizer in the signal cavity. The maximum pulse energy obtained was 66 µJ at a repetition rate of 1.4 kHz and a maximum average power of 120 mW at a repetition rate of 2.5 kHz. The pulse with a Gaussian intensity distribution had a duration of 17 ps measured with an autocorrelator, and a bandwidth of 1.2 nm. This system was not tunable. To achieve tuning the KTP crystal was replaced by a 40 mm long $LiNbO_3$ crystal. Using critically phase matched angle tuning we performed tuning from 1422 to 1650 nm as preliminary results. The pulse duration was typical 25 ps.

1. U.J. Greiner and H.H. Klingenberg, Opt. Lett. 22, 43 (1997).
2. D.R. Walker, C.J. Flood, H.M. van Driel, U.J. Greiner, and H.H. Klingenberg, Appl. Phys. Lett. 65, 1992 (1994).

10:15
TuD4

FREQUENCY CONVERSION IN PERIODICALLY POLED NONLINEAR CRYSTALS: POSSIBILITIES, STATE OF ART, PERSPECTIVES, AND LIMITATIONS.

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Nonlinear crystals with regular domain structure (RDS) attract great interest because of possibility to realize quasi-phase matching (QPM) for nonlinear optical processes. QPM techniques allow to use nonlinear materials for which birefringent phase matching isn't possible, to maximize nonlinearity of the materials, to realize such "exotic" nonlinear processes as backward second harmonic generation, optical parametric oscillation with backward wave, etc. There's a principle possibility of simultaneous realization of many nonlinear optical processes in RDS crystals (for example simultaneous generation of second and higher harmonics, optical parametric oscillation with low-frequency pump, and with divisible parametric frequencies). That is why RDS crystals may be widely used in optics investigations and applications.

In this paper, we discuss modern state of art of laser frequency conversion problem in RDS crystals, of it's progress, and some peculiar limitations. The numerical analysis was carried out using mathematical technique of reduced equations for coupled waves and Fourier-optics nonlinear diffraction equations. The results of preliminary analysis for multiwave generation in RDS crystals are presented. We took in consideration about 4000 possible combinations of nonlinear wave interaction. Expressions for effective nonlinearity are presented for different orientations of grating wave vector. The effect of pump depletion and coherent length dependence on pump intensity are analyzed too. Methods of suppression of undesirable nonlinear optical processed are considered. Peculiarities of noncollinear interaction in RDS crystals are analyzed.

Results of experimental investigations of laser frequency conversion in facet-type regular domain structure in $LiNbO_3$:Y:Mg crystal are presented.

10:30
TuD5

Investigations on CW Resonant Four-Wave Mixing Cycles in Diatomic Molecules

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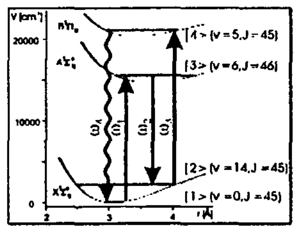
Summary

Fully resonant cw difference-frequency mixing processes $\omega_4=\omega_1-\omega_2+\omega_3$ are investigated using rotational-vibrational levels of the X, A and B electronic states of Na_2. In the shown cycle, a pump field λ_1=655 nm from a single frequency cw-dye laser is used to operate a cw Raman laser at λ_2=756 nm. These two fields and an additional field at λ_3=532 nm from a frequency-doubled diode-pumped Nd:YAG laser generate the forth field at λ_4=480 nm.



The Raman pair (λ_1, λ_2) realizes a coherent coupling of the levels 1 and 2 which supports the generation process by reducing the absorption at the 1-4 transition, which is more than 99% without the pump fields. With pump powers around 100 mW of the fields $\lambda_1,\lambda_2,\lambda_3$, an output power of so far 0.1 mW has been achieved.

Dependences on the pump power, the field detunings and differences between up- [2] and down-conversion [1] cycles will be presented and interpreted by recent model calculations [3]. For strong fields λ_1 and λ_3 exponential growth of the fields λ_2 and λ_4 is expected. Attempts to enhance λ_4 in an optical resonantor are in preparation and will be discussed.

[1] S.Babin et al., Opt.Lett. 21, 1186 (1996)

[2] A.Apolonskii et al., Appl. Phys. B 64, 435 (1997)

[3] A.K.Popov, B. Wellegehausen, Laser Physics 6, 364 (1996)

11:15-12:45 **RED HALL**

TuE - Fundamental Aspects of Laser-Matter Interaction II

Presider: *E.A. Manykin, State Scientific Ctr. "Kurchatov Institute" Russia*

11:15
TuE1
(Invited)

PHOTODESORPTION FROM DIELECTRIC SURFACES: TRANSITION FROM NONTHERMAL TO PSEUDOTHERMAL REGIME

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Two different regimes of photodesorption of alkali atoms from the surface of sapphire were discovered experimentally. In the low intensity regime the flux of desorbed atoms was found to be proportional to the laser intensity. For larger intensities the photodesorption signal rose exponentially.

Maxwellian velocity distribution fits well in both cases but the effective temperature which is constant in low intensity regime rises at larger intensities. On the other hand, because of transparency of sapphire to visible light the heating of the substrate is negligible even for the highest intensity used in the experiment.

A model that accounts for the experimental findings is proposed. The energy of an absorbed photon is assumed to be distributed at random between a large number of degrees of freedom, one of which leads to the desorption process. As the probability of desorption is very low, the most part of the excitation energy remains in the adsorption complex. At low laser intensity the relaxation rate exceeds the rate of absorption. In this case the effective temperature of desorbed atoms does not depend on the laser intensity. In the high intensity regime there is not enough time for the excitation to be transferred to the bulk. Hence, the effective temperature of the adsorbed atom rises in the course of consecutive absorption events. That leads to the exponential increase of the desorption probability.

The phenomena discussed above are caused by the low vibrational relaxation rate of adsorbed atoms. This quantity was estimated using the measured threshold intensity at which a transition from a nonthermal to pseudothermal regime took place. Its numerical value of 10^{10} s^{-1} agrees well with the independently-measured sticking coefficient of the atoms impacting a surface.

11:45
TuE2
(Invited)

FROM PHOTON ECHO TO OPTICAL PROCESSORS

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The contemporary state of the investigations of photon echo and other optical transient phenomena is discussed in this report. Since the phase memory lays in base of all these effects, they may be used in work of the optical processors. The modern laser technique allows to realize the various regimes of excitation of the photon echoes' diversity. Now the experiments are transfered to the femtosecond diapason of durations. It permits to make the investigation of ultrafast processes in condensed media at room temperature. The special attention is paid to phenomenon of the long-lived stimulated photon echo (LSPE), since just one possesses by perspectives of use in work of the optical echo-processors. This phenomenon is formed in the three-level system (but not in the two-level system, as the ordinary photon echo), when one level is metastable. The Van-Vleck paramagnetic crystals doped by rare-earth ions (such as Pr^{3+}, Eu^{3+}, Tb^{3+}, Tm^{3+} and Ho^{3+}) are used as information medium. As a rule, the experiments are carried out at the liquid helium temperatures, when the life time of the metastable level may achieve few hours. As a matter of fact, this time is one of optical phase memory and the time interval between the second and readout pulses may be changed from few μs to few hours. The physical principles of the optimal function of the optical processors based on LSPE are analysed in details. The special attention is paid to the multipulsed and multichannel regimes. Scheme of one-position optical memory device, realized in Kazan Phys.-Tech. Institute of RAS, is discussed. The principles of the echo holography (including the color one) are analysed and the ways of its using in the echo-processor's function are considered. The investigations devoted to creation of the echo-processor, based on the Hopfield-Little model of the cell computer, are also discussed.

12:15
TuE3

THEORETICAL INVESTIGATIONS OF SECOND-HARMONIC GENERATION IN A NONCENTROSYMMETRIC LIQUID BY A FOCUSED LASER BEAM

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Coherent second-harmonic generation (SHG) was recently detected in the bulk of a noncentrosymmetric liquid suspension of bacteriorhodopsin-bearing fragments of *Halobacterium Halobium* purple membranes [1]. The dependence of the second-harmonic intensity on the fundamental-beam intensity was not parabolic, but could be only approximated with a fourth-order polynomial, what was interpreted as the interference of three- and five-wave-mixing processes. We explain the arising of such coherent second-harmonic wave and propose two SHG mechanisms that could be responsible for the signal generation. The first mechanism is based on the nonlocality of the quadratic optical response of the medium together with the existence of a longitudinally polarized field component of a focused pump beam and the admixture of differently polarized higher-order transverse modes in it [2]. The second one is due to the local-type fourth-order optical nonlinearity in combination with the focusing of the beam. We obtained expressions for the electric field and for the powers of the second-harmonic waves generated through each SHG mechanism considered. For tight focusing of the pump beam in a long medium, the problem is studied in more detail. In this case, we discuss the transverse distribution of the signal-wave intensity as well as the dependencies of the signal power on the polarization state of the pump beam and on the wave-vector mismatch.

1. A. V. Balakin, D. Boucher, N. I. Koroteev *et al.*, Zh. Eksp. Teor. Fiz. **112**, 97 (1997) [English translation: JETP **85**, 52 (1997)].
2. S. N. Volkov, N. I. Koroteev, V. A. Makarov, Zh. Eksp. Teor. Fiz. **113**, issue 5 (1998) [English translation: JETP **86**, no. 5 (1998)] *(to be published)*.

12:30
TuE4

Studies of Nonlinear and Correlation Effects in the Continuum of an Elementary Atomic System Using Sequential Double Photoionization of Negative Ions

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Studies of the structure and dynamics of stable and autoionizing negative ions are of fundamental interest in atomic physics, since electron correlations play a decisive role in connection with their existence and decay. An introduction of new nonlinear laser techniques [1] based on a combination of laser photodetachment and the collinear resonant photoionization method [2] has recently allowed significant progress in the field. Structural and dynamic properties for a number of weakly bound systems have been established with an accuracy several orders of magnitude better than previously possible [3]. In the present talk we will report investigations of nonlinear near-resonant photoeffects in the continuum in the low intensity domain (~10^5W/cm^2), where the behaviour of an atomic system is not overcomplicated by saturation and depletion effects. We will show that even at these low intensities (~10^4 lower than has been observed before), excess-photon absorption signals can reveal sublinear dependence on laser power and resonant peak positions can deviate significantly from the actual positions of the involved autoionizing states. Feasibility of an extension of the step-wise excitation spectroscopy beyond the Isolated Core Excitation scheme is demonstrated. Moreover, we will present the first high-resolution spectra of the Wannier-ridge region obtained by measuring a partial photodetachment cross section for generation of the atom in a Rydberg state (n>12). We demonstrate that threshold behaviour is determined rather by Wannier model predictions, than by the characteristic for low-lying states Wigner threshold law. Above threshold, rich spectra of broad and narrow double-Rydberg resonances are observed, with both electrons having about equal excitation level.

1. V.V.Petrunin, J.D.Voldstad, P.Balling, P.Kristensen, T.Andersen, and H.K.Haugen, Phys.Rev.Lett. 75, 1911 (1995); V.V.Petrunin, H.H.Andersen, P.Balling, and T.Andersen, Phys.Rev.Lett. 76, 744 (1996);P.Kristensen,C.A.Brodie,U.V.Pedersen,V.V.Petrunin,T.Andersen, Phys.Rev.Lett. 78, 2329 (1997).
2. S.A.Aseyev, Yu.A.Kudryavtsev, V.S.Letokhov, and V.V.Petrunin, Opt.Lett.16, 514 (1991).
3. T.Andersen, H.H.Andersen, P.Balling, P.Kristensen, and V.V.Petrunin. Topical review. J.Phys.B: Atom.Mol.Opt. Phys. 30, 3317 (1997).

11:15-12:45 **GREEN HALL**
TuF - Ultrafast Phenomena II
Presider: *E. Ippen, Massachusetts Inst. Of Technology, USA*

11:15
TuF1
(Invited)

ON ULTRASHORT LIGHT PULSES PROPAGATION IN NONLINEAR MEDIA.

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Progress in the field of generation of femtosecond pulses makes it necessary to revised theoretical models of the pulses propagation in nonlinear dispersive medium. Indeed, derivation of the evaluation equations for electromagnetic radiation is often based on the approximation of slowly varying complex envelopes of the optical pulses. It is of interest to find a method of describing ultrashort pulse (USP) evolution *without using the slowly varying envelope approximation.*

A typical model of the nonlinear medium is an ensemble of N-level atoms. So, we can point out the conditions that determine different degrees of approximation in the theory of interaction and propagation of optical pulses in resonance media.

Resonance condition. The USP spectral width is far smaller than the resonance frequency. The wave equation in this case is complemented by the Bloch equations.
Unidirectional propagation condition. When concentration of the resonance atoms is sufficiently low, we can neglect the interaction between the counter-propagating waves.

At N = 2 the Maxwell-Bloch equations were considered in the case of resonant transitions: $j_a = 1 \rightarrow j_b = 0$, $j_a = 0 \rightarrow j_b = 1$ and $j_a = 1 \rightarrow j_b = 1$. The solution in the form of steady state pulse, describing the shortest polarized light, was obtained.

Ultrashort pulse propagation was observed under quasi-resonance condition, taking into account the polarization of the wave. The amplitude of the USP can be such that the Rabi frequency is small in comparison with the minimum atomic transition frequency. Hence, the Maxwell-Bloch equations can be transformed into some vector nonlinear wave equation. The new solutions of this wave equation were founded.

We present a model, in which Rabi frequency is greater than the minimum of atomic transition frequency. In this limit the anharmonic vector oscillators represent the nonlinear material response. Under some conditions the analytical results can be obtained.

11:45
TuF2
(Invited)

Ultrafast Carrier Dynamics in Semiconductor Nonlinear Bragg Reflectors

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Kiyoshi Ouchi
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Constructive interference of optical waves in Bragg reflectors leads to the confinement of high density photons. This photon confinement has advantages of achieving ultrafast large optical nonlinearities. We investigated room-temperature carrier-induced optical nonlinearities in semiconductor nonlinear Bragg reflectors (SNBRs). Two types of SNBRs were investigated: (I) InP/InGaAs SNBR showing nonlinearities of hot carriers above the band-edge [1] and (II) quantum well (QW)/InP/InGaAsP SNBR for band-edge nonlinearities of two-dimensional excitons. The stop-bands of the SNBRs and the exciton resonance were designed to cover wavelength range around 1500nm for applications to optical fibre communications.

The carrier-induced optical nonlinearities were characterised by transient reflectance measurements using a femtosecond optical parametric oscillator.

(I) In the InP/InGaAs SNBR, the decay in the transient reflectance was limited by relaxation time of the hot carriers. The relaxation time was about ≈100fs or shorter, much faster than in bulk InGaAs at the same level of photoexcitation. Carrier density dependence of the relaxation time was fitted with a model for carrier-carrier scattering [2]. Carrier-carrier scattering was enhanced in the InP/InGaAs SNBR since the carrier density in the InP/InGaAs SNBR was more than 10 times higher than in the bulk InGaAs because of the photon confinement.

(II) The band-edge responses of the QW/InP/InGaAsP SNBRs showed ultrafast nonlinear absorption at wavelengths detuned $\leq$20nm from the exciton peak. The nonlinear absorption was limited only by the temporal profile of the optical pulses and considered to be a coherent process reported as carrier-induced two-photon absorption (TPA) in multiple QWs [3]. The magnitude of the carrier-induced TPA was enhanced in this SNBR. The QW/InP/InGaAsP SNBR is expected as an optoelectronic structure suitable for ultrafast large excitonic nonlinearities.

This work was performed under the management of the Femtosecond Technology Research Association supported by the New Energy and Industrial Technology Development Organization.

[1] K. Ogawa etal, Appl. Phys. Lett. **72**, 155 (1998).
[2] D. W. Snoke, Phys. Rev. **B50**, 11583 (1994).
[3] H. K. Tsang etal, Appl. Phys. Lett. **62**, 1451 (1993).

12:15
TuF3
(Invited)

Femtosecond Cr:LiSGaF and Cr:LiSAF laser: Phenomena and limitations in the 15 fs-regime

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Summary

We give an overview over our latest works on the mirror-dispersion-controlled (MDC) Kerr-lens mode-locked (KLM) Cr:LiSGaF and Cr:LiSAF lasers, aimed at obtaining sub-20 fs pulses. Such lasers, in comparison to their prism-controlled forerunners, are distinguished by the high reproducibility, stability and quality of the pulses, as well as the compactness of the cavity. The shortest nearly bandwidth-limited pulses of ~14 fs duration have been produced in a Cr:LiSGaF laser, having an average output power of 100 mW.

Furthermore, in this paper we present the results of experimental investigation of the phenomenon of pulse self-frequency shift in Cr:LiSGaF and Cr:LiSAF lasers relatively to Ti:Sapphire lasers via mode-locking experiments and Raman spectra as well as gain measurements, and compare them with theory.

We also present and compare the results of the analytical analysis of the effects of higher order dispersion (HOD, up to any order) in mode-locked solitary lasers with numerical simulations and direct experimental results, obtained in the MDC Cr:LiSGaF and Cr:LiSAF lasers. Such analysis, taking into account arbitrary HOD, has been done for the first time to our knowledge. Since recent advances in dispersion compensation techniques make engineering of any required dispersion function quite feasible, we believe that the obtained results represent an important tool for dispersion-engineering.

11:15-12:45 **BEIGE HALL**
TuG - Quantum and Atomic Optics II
Presider: *H. Walther, Max-Planck-Institute of Quantum Optics, Germany*

11:15
TuG1
(Invited)

LIGHT-MATTER COHERENT ATOMIC BEAM SPLITTER.

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Summary. Atom interferometry becomes the item of top interest in the field of atom optics and physics as whole. *Coherent beam splitter is a key element of atom interferometer.* Sensitivity of atomic interferometers proportional to its area. Because of this the most important beam splitter parameter is value of coherent splitting of the atom wave function in the momentum space, that is angle of splitting. The scheme of beam splitter based on *reflection* and *diffraction* by standing evanescent wave now seems to be the most perspective [1]. Simple evaluation predicts the angles of the splitting of several tens mrad for thermal beams. Unfortunately the population of nonzeroeths diffraction orders under available evanescent wave laser power is negligible due to smallness of the period of the optical potential [2].

We propose a new method for the formation of light field that can be used to implement diffraction of atoms. The diffraction grating consist of metal strips on a surface of glass that irradiated by a light wave incident at the of total reflection angle. The resulting light field induced near the surface is modulated in intensity; this field reaches its maxima above open glass section of the surface. Photon Tunneling Scanning Microscope was used to measure the intensity distribution of light above the diffraction grating.

The calculated diffraction pattern of precoold sodium beam shows the efficient population of the first diffraction order.

1. C. Henkel, J.-Y. Courtois and A. Aspect, J. Phys II (Paris) (1994) 1955.
2. R.Deutschmann, W.Ertmer, H.Wallis, Phys. Rev. A47 (1993) 2169.

11:45
TuG2
(Invited)

INVERSION CONDITION FOR COHERENT BOSE-CONDENSATE FORMATION AND DYNAMIC EQUATIONS OF AN "ATOM LASER"

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The Bose-condensate is often associated with the coherent states of particles. It is taken for granted that the Bose-condensation gives automatically rise to the coherent state. But the laser physicist will hardly accept this postulate without any proof. The photons may be produced in a single mode of a laser cavity due to the *spontaneous* transitions when a laser is below threshold. But such a state of electromagnetic field will not be coherent. The coherent state of electromagnetic field (photons) is generated in the laser due to *stimulated* transitions when a laser is above a threshold (self-excitation *conditions*). *The analogous conditions are necessary for the achievement of coherent* states of any Bose-particles as well.

It is shown that condition analogeous to lasr inversion population has a form

$$n(\varepsilon) > \left[\exp\left(\frac{\varepsilon}{kT}\right) - 1\right]^{-1} \quad (1)$$

The right-hand part of Eq.(1) is nothing but the equilibrium function of the particle distribution outside Bose-condensate. So, even a small violation of equilibrium distribution towards increasing in the number of particles with energy ε leads to the production of an inversion state

To describe the dynamics of the atomic Bose-condensate one should use the Gross-Pitaevsky equation for an order parameter Ψ of the Bose-condensate

$$i\hbar\frac{\partial}{\partial t}\psi(\bar{r},t) = \left(-\frac{\hbar^2}{2m}\Delta + V(\bar{r},t) + U|\psi(\bar{r},t)|^2\right)\psi(\bar{r},t) \quad (2)$$

Since Bose-gas at the temperature above absolut zero consists of the *coherent Bose-condensate* and a subsistem of *incoherent* particles, coupling the order parameter with the incoherent part of the particvles is required in order to describe an "atom laser" dynamic. *Thise problems will be discussed in the paper.*

12:15
TuG3
(Invited)

ENTANGLING ATOMS WITH LIGHT

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The research program is described based on a novel approach to the problem of mapping of non-classical properties of light onto atoms. In most previous attempts the efficient coupling between the light and an atom necessary for such mapping has been achieved by using high finesse cavities. The novelty of our approach is that instead of trying to efficiently address a single atom in a cavity we send a beam of non-classical light through an optically thick ensemble of many atoms where the efficient mapping is achieved via complete absorption of the light. In this fashion we create an entanglement between different atoms of the ensemble which interact with different quantum correlated photons. Multilevel atoms, e.g. in the V-type configuration are necessary in order to create such an entanglement. An example of the implementation of those ideas is a recent proposal to generate Spin Squeezed States (SSS) of atoms via complete absorption of squeezed light [1]. Along the same lines creation of two quantum correlated atom ensembles, e.g., in two magneto-optical traps (MOTs), via interaction with two EPR beams from an optical parametric ocsillator (OPO) also seems feasible.

In order to demonstrate the feasibility of observation of quantum correlations between individual atomic spins we have recently addressed experimentally the problem of quantum noise of an atomic polarization measurement [2]. We have demonstrated that quantum noise of atomic spins in an excited state trapped in a MOT can be comparable or even larger than quantum (shot- or sub-shot-) noise of the probe light, and therefore the former is quite measurable. We have observed $\sqrt{N}$ (N-number of atoms) dependence of the spin noise characteristical for quantum spin noise for N up to 10^9 in a MOT. We have also demonstrated the sub-shot-noise polarimetry of cold atoms for an optically thin MOT with 2.5 dB noise reduction beyond the standard quantum limit. Observation of quantum spin noise in a MOT allows us to consider the implementation of the proposal [1] for SSS generation. The progress with this experiment will be reported. Future plans for generation of long living entangled atoms via Raman coupling to the non-classical light will be outlined. Storage of quantum states of light (e.g. quantum cryptographic states) in trapped cold atoms will be also discussed.

1. A. Kuzmich, K. Mølmer, and E. S. Polzik, Phys. Rev. Lett., December 15, 1997.

2. J. Sørensen, J. Hald, and E. S. Polzik, submitted to Phys. Rev. Lett., November 1997.

11:15-12:45 **BLUE HALL**

TuH - Nonlinear Optical Phenomena II

Presider: *G. Stegeman, CREOL, Univ. Of Central Florida*

11:15
TuH1
(Invited)

CHIRALITY IN NONLINEAR OPTICS: LOCAL AND NONLOCAL EFFECTS

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Since the discovery by L. Pasteur of the inter-relation between molecular chirality and optical activity in the end of 19-th century, spectroscopic techniques of circular dichroism (CD) and/or optical rotation (OR) have become major physical tools in studies of molecular enantiomophism (discrimination between left and right mirror symmetrical molecular pairs) [1]. However, in linear optics molecular chirality manifests itself only via nonlocal effects due to electro-quadrupole and magneto-dipole interactions which are usually small in comparison with local ones. As a result, linear optical techniques of CD and OR lack the necessary sensitivity and selectivity to study several features that are of paramount importance in our understanding of chiral molecular and supramolecular structure and its dynamics.

In contrary, chiral-specific nonlinear optical response (due to even-order nonlinear optical polarization) of isotropic media comprised of left/right mirror-asymmetric molecules in nonracemic concentration is entirely characterized by local interactions (both in the bulk and at interfaces) described by even-order electro-dipole nonlinear optical susceptibilities [2]. In combination with inherent interplay of additional degrees of freedom in frequency, time and polarization domains, local even-order nonlinear optical techniques provide unique possibilities in selectivity, discrimination with respect to the background and following up in time of key features of molecular chirality. These advantages by far compensate for the inherent complexity of nonlinear optical interactions. They are obtained through a rich and specific resonant and multiresonant behavior of the relevant nonlinear optical coefficients, characteristic tensorial coupling very sensitive to the chiral symmetry, selectivity both in frequency and time domains. The latter allows to study dynamical aspects as well when using ultimately short femtosecond laser pulses. In general, the use of trains of femtosecond laser pulses is far advantageous in exploiting chiral-specific nonlinear optical effects due to high peak power which is enhancing the efficiency of nonlinear interaction in combination with relatively low average power allowing to avoid the damage of labile chiral organic molecules [3].

The local chiral-specific nonlinear optical techniques include such effects as sum- and difference frequency generation both in the bulk and at the surfaces [4], second harmonic generation in reflection off the surfaces of chiral liquids [5], linear electro-optic effect (electrical analogue of magnetic Faraday rotation)[4], circular electrodichroism (difference in absorption coefficients for left/right circularly polarized light waves in the presence of quasi-static electrical field) [6], optical rectification [2], photo-voltaic effect [7], five-wave mixing in noncollinear beams [2, 8]. The nonlocal chiral-sensitive nonlinear optical techniques due to magneto-dipole and electro-quadrupole bulk and surface interactions (nonlinear optical activity, Raman nonlinear optical activity etc.) are also applicable in chiral discrimination, but their use is limited due to intrinsic lower sensitivity and higher background with the notable exemption of bulk magnetic-field-induced second harmonic generation [9].

References

1. S. F. Mason, Molecular optical activity and the chiral discrimination (Cambridge University Press, 1982). 2.N. I. Koroteev, in: Frontiers in Nonlinear Optics. The Sergei Akhmanov Memorial Volume, Eds. H. Walther, N. Koroteev and M. Scully (Institute of Physics Publ., Bristol, 1993), p. 218. 3. A. V. Balakin, D. Boucher, E. Fertein et al. , Opt. Commun., 141, 343 (1997). 4.N. I. Koroteev, Zh. Eksp. Teor. Fiz., 106, 1260 (1994) (Engl. transl. JETP, 79(5) 681 (1994)). 5.T. Petralli-Mallow, T. M. Wong, J. D. Byers et al., J. Phys. Chem. 971, 1383 (1993), M. Kauranen, T. Verbiest, J. J. Maki et al., J. Chem. Phys., 101, 8193 (1994). 6. N. I. Koroteev, Pis'ma. Zh. Ekp. Teor. Fiz., 66, 515 (1997) (Engl. transl. JETP Letters, 66, 549 (1997)). 7. N. I. Koroteev, Pis'ma Zh. Eksp. Teor. Fiz., 61, 83 (1995) (Engl. transl. JETP Letters, 61, 87 (1995)). 8. A. P. Shkurinov, A. V. Dubrovskii, N. I. Koroteev, Phys. Rev. Lett., 70, 1085 (1993). 9. N. V. Cohan, H. F. Hameka, Physica, 38, 320 (1967).

11:45
TuH2
(Invited)

Generation of the radiation with increased fluctuations in broadband stimulated Raman scattering

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Stimulated Raman Scattering (SRS) is a traditional method for laser frequency conversion, laser pulse compression, coherent laser beam combination. In our report we show that SRS at broadband pumping generates the Stokes radiation with increased fluctuations. This feature can be important for many applications when interaction is sensitive to the radiation statistics. It is also of interest as a possibility to generate the radiation with new statistical characteristics.

A comparison of experimental and numerical results for broadband and coherent pumping demonstrates different behaviors of Stokes pulse energy statistics in all regimes of SRS (linear, intermediate and nonlinear). It is shown that in the linear regime the Stokes pulse energy fluctuates with normalized standard deviation of more than 200 % that is an evidence of the super-Gaussian field behavior. This conclusion was confirmed by the simplified analytical consideration and by the results of numerical calculations based on the white noise model for the description of the pump radiation. The existence of the bimodal distribution of the Stokes pulse energy at broadband pumping was experimentally observed in the intermediate regime, it differs from the coherent case in which the distribution has only one maximum. This finding is also supported by the results of the numerical calculations. Experimental and numerical data obtained for the nonlinear regime demonstrate the decreased conversion efficiency and increased fluctuations scale of the Stokes pulse energy in comparison with the coherent pump case.

Possible applications of the radiation generated in broadband SRS will be discussed.

12:15
TuH3

STIMULATED LIGHT SCATTERING BY SPHERICAL AEROSOL PARTICLES IN RESONANT CONDITIONS.

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Stimulated light scattering in the aerosol particles, is accompanied by the excitation of a number of electromagnetic, elastic and other degrees of freedom in the particles [1]. Electromagnetic modes, with strongly inhomogenious field distribution and low loss factor (Q-factor up to 10^7-10^9 for 'Whispering Gallery Modes') play an exceptional role in the stimulated scattering.

The analyze of numerous mechanisms of stimulated scattering could be reduced to the problem of coupled oscillations, when the wave interactions in aerosol particles are described by the set of equations:

$$\ddot{A}_f + \omega_f^2 A_f = -R_{fa}\dot{A}_a - N_{fabc} A_a A_b A_c - I^*_{faw} A_a B_w - H_{fas} A_a \eta_s - W_{fam} A_a \zeta_m + F_f(t)$$

$$\ddot{B}_w + \Omega_w^2 B_w = -\theta_{wr} \dot{B}_r - I_{wab} A_a A_b$$

$$\dot{\eta}_s + \lambda_s \eta_s = K_{sab} A_a A_b$$

$$\ddot{\zeta}_m + \overline{\omega}_m^2 \zeta_m = -\Lambda_m \dot{\zeta}_m - M_{mab} A_a A_b \qquad (a, b, c, f, w, s, m = 1,2, \ldots)$$

Different kinds of scattering are associated with the parametric excitation of acoustic ($B \neq 0$, Stimulated Brillouin Scattering, SBS), temperature ($\eta \neq 0$, stimulated Thermal Scattering, STS), and molecular ($\xi \neq 0$, Stimulated Raman Scattering, SRS) oscillations. The power thresholds of excitation could be drastically reduced under resonant conditions , while electromagnetic pump and parametrically excited and combinational oscillations have the frequencies equal to eigenfrequencies of corresponding modes of the particle [2,3].

The efficiency of different excitation mechanisms and the variety of the coupled mode combinations are determined by the integral coefficients (I, I*, H, K,M, N), which are dependent on nonlinear parameters of substances and the spatial mode overlap. The analysis of oscillation dynamics and the calculations of integral coefficients for spherical aerosol droplets was done in this work. The estimations of power threshold for water droplets show the pump level in the limits 10^2-10^5 Wt/sm^2 both for SBS and SRS, depending on the droplet dimension and mode numbers.

The effect of the nonlinear detuning (both of Kerr ($N \neq 0$) and thermal nature) on the dynamics of the resonance stimulated light scattering is investigated. The explanations of the experimentally observed results of lowering SRS thresholds pump in the presence of SBS oscillations in the droplets is suggested in terms of low loss mode interaction.

1. Zemlyanov A.A., Geints Yu.E., Opt. atmosf.1997,Vol 10, №4-5,p.500-515.
2. Belokopytrov G.V., Puschechkin N.P. Izv. Vuzov-Radiofiz.1992,№ 6-7,p.498-510.
3. Belov N.N., Belokopytov G.V., Jouravlev M.V. J.Aerosol.Sci., 1997, Vol 28, Suppl1., p.201-202.
4. Biswas A.R. et al., Phys. Rev. A, 1989, Vol 40, № 11, p.7413-7416.

12:30
TuH4

Temporal behavior of cascaded three wave mixing

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β–BBO crystal is an efficient material for three wave mixing processes like SHG, OPO or OPA. Choosing type I phase matching, we have studied the cascaded $\chi^{(2)}$ induced phase temporal caracteristics on the fundamental pulse. The studied cascaded $\chi^{(2)}$ resulting wavelength is the fundamental one. This cascaded effect can be compared with a $\chi^{(3)}$ nonlinearity n_2 : it is 50 times greater in β–BBO, and by detuning the phase matching one can choose the phase shift sign[?].

Using a time resolved experiment [?], we have measured in the femtosecond regime the time dependence of the phase shift during SHG, frequency summation and OPA processes. Because of group velocity mismatch between the pulses, the temporal dependence of the cascaded $\chi^{(2)}$ phase is asymmetric with regard to the pulse temporal amplitude center. This implies an associate nonlinear chirp. This chirp, previously calculated[?, ?] but never measured before to our knowledge, is difficult to compensate and limits the use of this efficient ~~cascaded~~ $\chi^{(2)}$ n_2.

14:00-16:15 **RED HALL**

TuI - Fundamental Aspects of Laser-Matter Interaction III

Presider: *V.A. Makarov, M.V.Lomonosov Moscow State Univ., Russia*

14:00
TuI1
(Keynote)

About the coherent Bremsstrahlung harmonics creation in laser plasmas.

V.P.Silin.

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The reason of the odd harmonics generation of the high power pump field in plasmas is the Bremsstrahlung of the electrons scattering by ions when electrons oscillate in the coherent field of the pump wave. The extension of our old theory (ZhETF, v.47, 6, p.2254(1964)) for the case of the pump field elliptical polarization permits us to find new dependencies of the intensity of harmonics and their polarization as the functions of numbers of harmonics. The model of cold plasmas gives in the case of the small A- the degree of the pump field circular polarization- the laws for effectiveness of the high order harmonics generation: $\eta^{(2l+1)} = \left[\nu(E,l)/\ 2\pi\omega l^2 A\right]^2$ and for the degree of the harmonic circular polarization: $A^{(2l+1)} = Al\left[2\ln(2/Al) - 0.577\right]$ where $\nu(E,l)$ is the effective collision frequency of electrons and ions in the strong pump field when the quiver electron velocity v_E is much larger than the thermal velocity v_T and $l >> A >> v_T/v_E$. It is necessary to underline that we obtain the approximate relation $\xi_3(2l+1) = -\xi_3$ between the third Stokes parameters of the (2l+1)-th harmonic and of the pump field (ξ_3). Therefore the approximate plane of the harmonics polarization is approximately perpendicular to the approximate plane polarization of the pump field. If we have the case of the hot plasmas ($A << v_T/v_E$) then we obtain

$\eta^{(2l+1)}(A=0) = \left[\nu^2(E,l)/8l^2\pi^2\omega^2\right]\left[\ln(v_E^2/2lv_T^2) - 0.577\right]^2$. The most important increase of the harmonics generation effectiveness we have in the warm plasma ($A << 3v_T/v_E$) case when $\eta^{(2l+1)} \approx \left[\nu^2(E,l)/2\pi^2\omega^2\right](v_E^2/8\ l^4 v_T^2)$. This result is much larger than effectiveness at $A=0$ because of the condition of the high order harmonics generation $(v_E^2/2l^2\ v_T^2) >> (\ln(v_E^2/2l^2 v_T^2) - 0.577)^2$.

This work is supported by the Russian Fond for Basic Research (96-02-17002) and by the State support of the leading scientific school (96-15-96750).

14:45
TuI2
(Invited)

INTERACTION OF QUANTUM SYSTEMS HAVING LARGE ANGULAR MOMENTUM VALUES WITH EXTERNAL FIELDS INCLUDING LASER FIELD

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In the last years multiphoton resonance radiative processes in atomic and molecular gases are investigated intensively for purposes of radiation frequency transformation, obtaining amplification without inversion, dispersion without absorption and other interesting phenomena. They used to analyze the problems of such a kind in the simplest model with nondegenerate states. The accounting of the energy states degeneracy with respect to angular momentum projections is of basic importance when considering polarization phenomena as well as for quantitative comparison with experiment. However in the ordinary quantum mechanics this accounting is practically unrealizable in the case of large J-values and high intensities. On the other hand for large J one may try to treat the rotational motion classically retaining the quantum approach to all other internal variables. The abilities of such semiclassical approach were demonstrated in our early works .

Our approach is based on a Wigner-type transformation of kinetic equations for the system's density matrix. This transformation, which is possible for large J, turns the rotational variables into parameters. That means that the rotational motion accounting turns into elementary generalization - introduction of angular variables (with subsequent averaging) into a previously obtained solution in the model of nondegenerate levels. In a more general case this transformation provides equations which generalize the Liouville equation and describe quantum transitions of rotating system caused by strong perturbation as well as the motion of angular momentum in this specific conditions.

We present the result of applying this method to the problem of multiphoton radiative interaction with multilevelsystems, to the description of polarization properties of Raman scattering and parametric generation in particular.

15:15
TuI3
(Invited)

INFLUENCE OF WEAK MAGNETIC FIELD ON LASER INDUCED OPTICAL PROCESSES IN ATOMIC VAPOR

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We report the results of absorption, fluorescence and crossed-polarizers laser spectroscopy of dilute Cs atomic vapor in weak external magnetic fields.

Radiation beam (parallel) of a 20 MHz-linewidth laser diode was directed into the 1.7 cm -long cell containing Cs. The typical density of Cs atoms was $9 \cdot 10^{10} cm^{-3}$ (room temperature). To obtain the transmission and fluorescence spectra, the laser frequency was linearly scanned within 22GHz spectral region around Cs D2-line(852nm) by means ofinjection current ramping. The maximum laser intensity was $40 mW/cm^2$. A longitudinal magnetic field variable in 0.009 -30 Gauss has been applied to the Cs cell.

Since the separation of the hyperfine sublevels of $6P_{3/2}$ state with F=2,3,4,5(150-200-250 MHz) is less than the Doppler broadening (400 MHz), the D_2 spectra consisted of two resolved lines only: $6S_{1/2}$ (F=3)$\rightarrow 6P_{3/2}$(F=2,3,4) (ν_3) and $6S_{1/2}$(F=4)$\rightarrow 6P_{3/2}$(F=3,4,5)(ν_4). The frequency separation of these lines is 9.2GHz caused by the hyperfine splitting of $6S_{1/2}$ ground state with F=3,4. The 70.1% and 80% absorption is observed on ν_3 and ν_4 lines, respectively, at the laser intensities below the saturation value($\sim$ 1 mW/cm^2), independently of applied magnetic field.

At higher laser intensities, we have observed an essential dependence of absorption on magnetic field, especially on ν_3 transition. Thus, at $40mW/cm^2$ excitation intensity the absorption coefficient for ν_3 line increases at 1.5 times by variation of magnetic field from 0.01 to 1Gauss. The same behaviour was observed in the fluorescence spectra.

Much more pronounced magnetic dependence reveals in crossed-polarizers configuration. No any transmitted light was recorded at low laser intensities ($\sim$ 1 mW/cm^2), at arbitrary values of magnetic field. An increase of intensity up to $40mW/cm^2$ leads to appearance of strong signals which are sensitive to magnetic field within 10^{-3} Gauss region around zero.

The results described above can be connected with coherent population trapping at zero magnetic field. The realization of this phenomenon in Na atomic beam excited by a single linearly-polarized laser was reported recently [1].

[1].F.Renzoni,W.Maichen,L.Windholtz,E.Arimondo,Phys.Rev.A, v.55, 3710(1977).

15:45
TuI4

POLARIZATION WOOD'S ANOMALIES

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The phenomena of sharp dependence of the diffracted waves intensity upon the incidence angle θ and radiation wavelength λ under the light diffraction on the surface with periodical relief are commonly called in the literature as Wood's anomalies. These anomalies are stipulated by resonant excitation of surface electromagnetic waves (SEW) and are manifested on grating with period $d \sim \lambda$ and relief depth $h \sim h_0$, where h_0 is optimal depth for the effect observation of total attenuation of specular reflection (in case of metallic gratings h_0=0.3-0.5 μm for λ=10.6 μm and h_0=30-50 nm for λ=0.5-0.8 μm).

Unlike it, we showed theoretically and experimentally that there is a new class of polarization Wood's anomalies which is manifested on gratings with $d \sim \lambda$ and $\lambda > h >> h_0$. Under resonant SEW excitation in this case there are no sharp dependencies of diffracted waves intensity upon θ and λ, but sharp dependencies of specular reflected wave polarization upon θ, λ and orientation angle ψ of the grating grooves.

In present paper we developed analytical theory of transformation of p-polarized incident wave into specular reflected linearly polarized radiation with rotation of polarization plane on an arbitrary angle β under light diffraction on metallic relief grating with $h >> h_0$. The possibility of almost 100 % energy efficiency of such conversion was predicted, including transformation of p-polarized radiation into s-polarized specular reflected wave. It was shown that the field of changing of β and the character of dependencies β upon θ and ψ are defined by relation λ/d and are strongly different for different regions $\lambda/d \geq 1.25$, $1.25 > \lambda/d \geq 1$ and $\lambda/d < 1$.

Experimental investigation of polarization transformation effect was fulfilled for radiation with λ=10.6 μm and 9.2 μm. The energy efficiencies (92-94 %) of conversion of incident radiation into specular reflected wave and corresponding dependencies β upon θ and ψ were measured for gratings with λ/d=1.493, 1.296, 0.883. The good quantitative agreement between theoretical and experimental results was demonstrated.

14:00-16:15 **GREEN HALL**
TuJ - Ultrafast Phenomena III
Presider: *E.M. Dianov, General Physics Inst., Russia*

14:00
TuJ1
(Invited)

Ultrafast Dynamics of Holes in GaAs Probed by Two-Color Femtosecond Spectroscopy

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The study of ultrafast relaxation dynamics of free carriers in semiconductors is a subject of fundamental importance and is being investigated extensively. Until recently most studies have focused on the investigation of the dynamics of electrons, while information about hole thermalization has remained scarce. This paper reports results on ultrafast dynamics of holes in GaAs measured using well synchronized femtosecond pulses at near-infrared and mid-infrared wavelengths which are available from a femtosecond optical parametric oscillator (OPO) pumped by a mode-locked Ti:sapphire laser. With this source, it is possible to pump valence-to-conduction band transitions with near-IR pulses and probe the generated holes with mid-IR pulses which can be tuned to resonance transitions between the heavy- or light-hole (HH,LH) bands and the split-off (SO) band. The clear advantage of this scheme is that, with suitably chosen pump and probe wavelengths, only carriers in the heavy- and light-hole bands interact with both pump and probe photons. Thus, the measured signal is completely free from contributions from the pump-photon-excited electrons. We used a 400mm-thick bulk pure GaAs sample (ne<1014cm-3) which was antireflection coated in the mid-IR (3-4mm range). The sample was pumped by pulses at 815 nm from the Ti:sapphire laser, and probed by pulses in the 3-4 mm range from the OPO. The pump pulse excites holes in the HH and LH bands with excess energies of ~12meV and ~44meV. =46or short probe wavelengths (lpr<3.6mm) the band filling factor due to LH (Dflh) is relatively small because of the large separation in k-space between the excitation and the probing points in the LH band. For long probe wavelengths (lpr>3.6 mm) the HH contribution vanishes because the probe photon energy moves off resonance for direct HH to SO transitions. Thus, there are two distinctive probe wavelength regions in which it is possible to measure a response primarily from holes in only one band (LH or HH). The transient spectra at different delay times and differential transmission signal (DT/T) for different probe wavelengths were measured. In contrast to previous conjectures, rapid hole burning effect followed by the establishment of a quasi equilibrium in less than 300-400 fs was clearly observed.

We have taken data for different excited carrier densities (2x1016-4.5x1017cm-3). The experimental details and the results will be discussed in this talk.

14:30
TuJ2
(Invited)

Paper is not available

15:00
TuJ3
(Invited)

NON - STATIONARY OPTICS OF ULTRASHORT SINGLE-CYCLE PULSES
IN DISPERSIVE MEDIA
(Exactly Solvable Models)

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SUMMARY

This report presents the first analytical time-domain model of interactions of picosecond and femtosecond waveforms, containing only one or few oscillations of EM field, with dispersive and conducting media. These fields are described by hitherto unknown exact analytical unharmonic and non-stationary solutions of Maxwell equations for continuous media. Such solutions are obtained directly in time domain beyond of the scope of traditional Fourier presentations and without the habitual separation of fields on time - dependent are coordinate - dependent parts (non-separable presentations). Visualizing the strong dependence of reflection and refraction of single - cycle waveforms upon their shapes and time scales, this non-Fourier optics permits one to optimize the parameters of such waveforms in the problems of non-stationary transfer of energy and information through dispersive and lossy media.

The following results of this approach are considered:

1. Benefits of using of non-sinusoidal transient fields for energy transfer through dispersive media.

2. Non-stationary waves in conducting media.

3. Processing of ultrashort transients and their discrimination from sinusoidal waves in a real time.

4. Shape- dependent and time-dependent reflection and refraction of single-cycle waveforms on the dispersive interface.

5. Shape-dependent selection of wideband transients versus the frequency filtration.

The new mathematical basis for this shaping topic in suggected, and such standard images of frequency domain optics as phase, frequency or refractive index prove to be needless for this time domain optics of non-sinusoidal waveforms. This new approach reveals the information, which was coded in Maxwell equations, but was not claimed yet.

15:30
TuJ4

COHERENT MODE LOCKING

Victor V. Kozlov

Department of Physics, Texas A & M University, College Station, TX 77843-4242

It is believed that a pulse generated through a mode-locking inside a laser cavity will have a finite duration that is ultimately limited by the gain bandwidth of the laser gain. However, unlike passive frequency-selective elements the dispersion of the amplifying medium presents a nonlinear function of intense field that allows it (contrary to the popular belief) to support pulses *with durations beyond the ordinary limit.* As a pulse becomes shorter than the phase memory time of a medium, the field-matter interaction is exhibiting coherent features. In this Report the properties of coherent nonlinear gain are utilized as a basis of a new mode-locking technique for generating pulses with durations *shorter than the inverse spectral width of the gain profile.*

The benefits of coherent medium-field interaction are twofold: the gain serves as an active medium and as a modulator for pulse formation.. Throughout the formation process a pulse in an amplifying two-level system evolves toward a π-pulse allowing the full release of the stored energy and moving with the velocity of light, [1]. The stability condition should be fulfilled by placing a cell with a passive medium into a cavity. A more plausible choice may be realized by using the *same* medium for the absorber as for the amplifier, but without external pumping. The coherent character of interaction between the pulse and the absorber may lead to a severe decrease in energy damping rate compared to that for cw radiation.

The detailed analysis of the model based on the analytical and numerical calculations will be presented in the Report, including the analytical derivation of the soliton-like solution, checking its stability, analysis of transient behaviour of the steady-atate regime, etc.

1 S.L. McCall and E.L. Hahn, Phys.Rev. **183**, 457 (1969).

15:45
TuJ5

Measurement of homogeneous spectra of impurity doped solids in a femtosecond single-shot mode

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To eliminate the inhomogeneous spectral broadening and to obtain narrow and informative homogeneous spectra of low temperature impurity doped solids several spectroscopic methods have been proposed: fluorescence line narrowing, spectral hole-burning, single-molecule spectroscopy and photon echo techniques. In traditional photon echo spectroscopy the intensity of the photon echo is measured as a function of the temporal delay between excitation pulses by varying the delay step-by-step. From these decay curves the relaxation times as well as the homogeneous spectra can be calculated. We demonstrate a novel approach of time-resolved spectroscopy which enables to detect the homogeneous spectra in single-shot, i.e. by exciting the photon echo sample only by two / three femtosecond pulses. The single-shot measurements could make possible to eliminate and study phenomena like spectral diffusion in pico- and nanosecond time-scales.A special experimental geometry is used to obtain at the output plane the spatial intensity distribution of a single photon echo pulse proportional to the autocorrelation function of the homogeneous spectrum. A thin sample of polyvinylbutyral doped with Zn-naphthalocyanine-type dye molecules is excited by three plane-wave femtosecond pulses (~100 fs and ~0.1 mJ per pulse). Due to the plane-wave excitation and counterpropagating geometry the delay between the pump pulses varies at the sample more than 100 ps. As a result the intensity distribution of the stimulated photon echo at the sample plane corresponds to the above described decay curve of the photon echo signal. A focusing lens behind the sample performs optical Fourier transform from spatial electric field amplitude distribution at the sample plane and depicts to the Fourier plane the intensity distribution of photon echo proportional to the autocorrelation function of the homogeneous spectrum. On this way homogeneous spectra are recorded with a CCD-camera at different temperatures from 2K up to 120K and a broadening of the homogeneous spectra and a decrease of Debey-Waller factor are observed.

16:00
TuJ6

Femtosecond Spectroscopy and Fermiology: New Possibilities for Correlated Electron System Study

Yu.E. Lozovik, A.L. Dobryakov, V. M. Farztdinov, S.A. Kovalenko†, Yu. A. Matveets, S. P. Merkulova

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The new method of investigation of Fermi surface and Fermi liquid (FL) versus non-Fermi liquid (NFL) behavior in strongly correlated electron systems by femtosecond laser spectroscopy is discussed. The method consists in study of spectral dependence of the nonequilibrium charge carriers relaxation time by pump-supercontinuum probe technique. This method is demonstrated on high T_c oxide- superconductor $YBa_2Cu_3O_{7-\delta}$ by studying the temporary changes of optical density of $YBa_2Cu_3O_{7-\delta}$ thin film in wide spectral region of probing $\hbar\omega_{probe} = 1.63-3.0eV$. The relaxation time sharply grows in the spectral area, related to optical transitions into the vicinity of Fermi level (or its shadow). The position of this peak gives the location of the Fermi surface (FS). The form of peak gives unique information on the damping rate of quasiparticles near FS and thus on the FL vs NFL behavior. The data are compared with experimental results for weak correlated electron systems in Au and Cu. Coherent phonon generation is discussed.

14:00-16:15 **BEIGE HALL**
TuK - Quantum and Atomic Optics III
Presider: *J. Mlynek, Univ. Of Konstanz, Germany*

14:00
TuK1
(Invited)

QUANTUM TELEPORTATION FROM OPERATIONAL POINT OF VIEW

D. N. Klyshko

Moscow State University, Moscow 119899, Russia

The remarkable opportunity of transferring the quantum state from one individual system onto another, isomorphic with the first, was recently suggested by Bennett *et al.* [1]. The first optical experiments with copying the polarization of one photon onto the other were described in [1,2].

The operational analysis of these experiments will be presented. Actually, in [1,2] specific varieties of the polarization interference are observed using the double [3] or triple [2] coincidences. Two polarization transformers T_{in} and T_{out} are installed into the input and output photon's paths. The dependence of the coincidence probability on the transformers' parameters reveals a surprising peculiarity – both transformers act according to the product of their Jones' matrixes $T_{out}T_{in}$, as if they both are put into the same beam.

The standard calculation shows that for a true polarization teleportation it is necessary to add into the scheme an optical gate G, monitored by the photodetectors: it is necessary for the elimination of "bad" copies. (These unlucky events happen half the time -- when two photons are hitting the same detector). Besides, an additional transformer T'_{out} is needed to double the percentage of "good" copies by performing sometimes the unitary operation $T'_{out} = \sigma_x$ on the output photon [1]. Thus it seems that at best only 50% of successful polarization teleportations could be achieved.

The hypothesis of the wave-function reduction, resulting from the measurements, is not necessary for the quantitative description of the observed effects: they are completely described by the standard algorithms of quantum theory and by the Born postulate, connecting the calculated correlation functions with the measured coincidence probabilities. It appears that at present the reduction concept is only a convenient accustomed notion, unsupported by any known experimental evidence.

1. C. H. Bennett *et al.*, Phys. Rev. Lett. 70, 1895 (1993).
2. D. Boumeester *et al.*, Nature **390**, 575 (1997).
3. D. Doschi *et al.*, Phys. Rev. Lett. **80**, 1121 (1998).

14:30
TuK2
(Invited)

Interference of fields and intensities in light scattering.

A.N.Penin

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This work was aimed at the study of statistics for light fields scattered in elastic, quasi-elastic, and nonelastic processes. The statistics was described by the second-order and fourth-order moments of field. The fourth-order intensity moment was measured both using the Brown-Twiss interferometer and by counting coincidences from Stokes and anti-Stokes radiation.

Three series of experiments have been carried out. In the first series, statistics of oppositely directed modes was studied for the process of elastic scattering by small particles. It was shown that the intensity correlation function contains information about the sizes and velocities of the particles. To obtain intensity correlation between oppositely directed modes, the scheme of counter-propagating pump beams was used.

In the second series, field and intensity correlation functions were investigated for light scattered (diffracted) by acoustic waves whose statistics was varied from coherent to thermal (Gaussian). The dependence of the scattered light correlation function on the statistical properties of the acoustic waves is obtained. For Gaussian statistics of the acoustic waves, the scattering gives a source of narrow-band quasi-thermal light with high (laser) brightness. By introducing positive feedback between the scattered light and the acoustic waves, it is possible to change statistics of the scattered light within a broad range. The resulting radiation has superthermal bunching parameter and resonant connection between the intensity and its second moment.

Finally, experiments were carried out for one of the types of nonelastic scattering, namely, for parametric scattering of light. Using correlation methods, life time of a photon in a cavity introduced into the idler channel is determined.

1. A.V.Burlakov, M.V.Chekhova, S.P.Kulik, and A.N.Penin, Laser Physics, v.6, No. 6, pp 1077-1081 (1996).
2. M.V.Chekhova, S.P.Kulik, A.N.Penin, and P.A.Prudkovsky, Phys.Rev.A, v.54, No. 6, pp.R4645-R4647 (1996).

15:00
TuK3
(Invited)

Quantum fluctuations in traveling-wave amplification of faint optical images

M.I.Kolobov, L.A.Lugiato and I.V.Sokolov

At present, there is an increased interest to applications of squeezed and other non-classical states of light to optical phenomena in spatial domain. It was shown recently that multimode squeezed states provide a possibility of reducing the quantum fluctuations of light not only in time, but also in the transverse cross-section of the light beam, i.e. in space [1]. This opens such possibilities as sub-shot-noise imaging of faint objects [2], creation of noiseless optical images by interference or polarization mixing [3], non-classical phenomena in the transverse pattern formation [4].

Kolobov and Lugiato have considered recently [5] a ring-cavity optical parametric oscillator below threshold and have shown that such a device operates as a phase-sensitive amplifier of faint optical images, preserving the signal-to-noise ratio. The cavity-based geometry ensures a continuous-wave regime of amplification.

Here we consider a traveling-wave version of the parametric image amplifier without external cavity. Such a geometry is more realistic for possible practical realizations. We demonstrate its advantages over the cavity-based counterpart. The most important ones are greater frequency and spatial-frequency amplification bandwidth. Greater frequency bandwidth allows one to amplify, for instance, pulsed optical images, while greater spatial-frequency bandwidth provides better resolving power of noiseless amplification, i.e. a possibility of amplifying fine details of a faint image.

The optimum signal-to-noise ratio of the amplifier is determined by quantum fluctuations of the input image. Since the amplifier is phase-sensitive, the effective noiseless amplification with high spatial resolution is possible only when phase matching is optimum for all spatial points of the input image. We evaluate conditions for such optimum phase matching and demonstrate a possibility for improvement of the signal-to-noise ratio for both ring-cavity and traveling-wave geometries. We also compare the resolving power in time and space for ring-cavity and traveling-wave noiseless image amplifiers.

[1] M. I. Kolobov and I. V. Sokolov, Zh. Eksp. Teor. Fiz. **96**, 1945 (1989) [Sov. Phys. JETP **69**, 1097 (1989)]
[2] M. I. Kolobov and P. Kumar, Opt. Lett. **18**, 849 (1993)
[3] I. V. Sokolov and Ya. A. Fofanov, Opt. Spektrosk. **74**, 764 (1993) [Opt. Spectrosc., **74**, 454 (1993)]
[4] L. A. Lugiato, A. Gatti, and H. Wiedemann, in *Quantum Fluctuations*, edited by S. Reynaud, E. Giacobino, and J. Zinn-Justin, Les Houches, Session LXIII (1995) (Elsevier, Amsterdam, 1997), p. 431
[5] M. I. Kolobov and L. A. Lugiato, Phys. Rev. A **52**, 4930 (1995)

15:30
TuK4

Generation of light with nonclassical polarization state *by means of optical frequency mixing*

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Polarized light with nonclassical state of polarization is called polarization – squeezed (PS) light. Generation of PS light in cubic nonlinear media has been studied in details for several years. However, to observe nonlinear optical phenomena and obtain nonclassical light it is preferable to use quadratic nonlinear crystals. We have recently shown [1] that PS light can be obtained in quadratic nonlinear crystals at second harmonic generation by frequency mixing of orthogonal polarized modes.

In this paper we report results of detailed research of polarization properties of fundamental radiation and second harmonic generated by mixing. The quantum polarization state is described by the Stokes operators. It is established that the fluctuation level of some Stokes parameters of both fundamental radiation and second harmonic can be less than that of a coherent state. Fundamental radiation experiences greater suppression of the Stokes parameter fluctuations than the second harmonic. One can obtain weak light at fundamental frequency with deeply suppressed fluctuations of the Stokes parameters.

We used two different methods for solving the problem under consideration. Short path approach describes the light frequency mixing process at comparatively short interaction lengths, while the method of perturbation is the best approach for comparatively significant conversion coefficients.

We consider a scheme of PS light registration and statistical properties of such light at the output of various optical elements.

[1] V.N. Beskrovnyi, A.S. Chirkin, Kvantovaya Elektronika, **23**, s. 843 (1996); Quantum Electronics, **26**, p. 2310 (1996) (English translation).

14:00-16:15 **BLUE HALL**
TuL - Nonlinear Optical Phenomena III
Presider: *F.V. Bunkin, General Physics Inst., Russia*

14:00
TuL1
(Invited)

Experiments on Bright Quadratic Solitons

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Summary: Although spatial solitons based solely on second order nonlinearities were first predicted in the 1970s by Sukhorukov and colleagues[1], they were not observed until the mid 1990s by Torruellas et al and Schiek et al at CREOL[2,3]. They consist of non-diffracting beams composed of all of the frequencies coupled together by almost phase-matched second order nonlinear interactions. Over 100 papers have been published in this field, most of them theoretical. Many of the features of quadratic solitons, their generation in planar waveguides and bulk media, their composition and their interactions have been observed. In this paper we will present an overview of the experimental work to date which will include:
(1) Quadratic soliton generation in planar waveguides and bulk crystals near and far from phase-matching with fundamental inputs for both Type I and Type II phase-matching geometries;
(2) Quadratic soliton generation in parametric down conversion geometries, both seeded and from "noise";
(3) The interactions between quadratic solitons and the dependence on their relative phase;
(4) The extensive family of quadratic spatial solitons in Type II geometries;
(5) Properties of "walking" solitons in geometries exhibiting walk off;
(6) Modulational instabilities leading to patterns of quadratic solitons;
(7) Beam clean-up during second harmonic generation.

References:

[1] Y. N. Karamzin and A. P. Sukhorukov, Sov. Phys.-JETP **41**, 414 (1976)
[2] R. Schiek, Y. Baek and G.I. Stegeman, Phys. Rev. E, **53**, 1138 (1996)
[3] W.E. Torruellas, et al, Phys. Rev. Lett., **74**, 5036 (1995).

14:30
TuL2
(Invited)

Paper is not available

15:00
TuL3
(Invited)

MAGNETO-OPTIC SPATIAL SOLITONS

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It would appear, that there has never been a better time to pursue the combination of nonlinearity and guided wave magneto-optics. A magneto-optic medium couples components of the propagating electric field through Q a magneto-optical parameter.

If x is the focusing direction, for two solitons in a third-order media, in the plane of the structure, $Q = Q(x)$, as shown in Fig. 1, and $\Delta = x_2 = -x_1$ where x_j are the positions of the soliton maxima, the interaction potential of two spatial solitons in a third-order nonlinear medium is

$$U(\Delta) = -4\mu\left[\frac{1}{\tanh^2(2\Delta)} - 1\right]\left[\frac{2\Delta}{\tanh(2\Delta)} - 1\right] + \frac{1}{2}\int Q(x)\operatorname{sech}^2(x+\Delta)dx - \frac{1}{2}\int Q(x)\operatorname{sech}^2(x-\Delta)dx$$

In the absence of a magnetic field, Fig. (2) shows that the collapse of a pair of solitons is inevitable, provided a long enough propagation distance is simulated. Fig. (3) shows, beautifully, that for $Q_0 = \pm\ 0.2$ the solitons either repel each other, or stay locked together, but remain apart. Finally, vector interactions in quadratically nonlinear media will also be discussed.

REFERENCES

1. A. D. Boardman and K. Xie, Phys Rev Lett 75, 1591 (1995).
2. A. D. Boardman and K. Xie, J Opt Soc Am B 14, 3330 (1997).
3. A. D. Boardman and K. Xie, Phys Rev E 55, 1899 (1997).

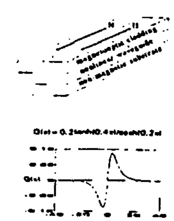

Figure 1. Magneto-optic structure

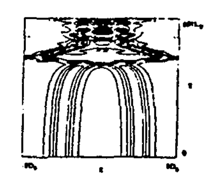

Figure 2. Collapsing spatial solitons in absence of applied magnetic field

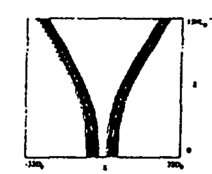

Figure 3. Spatial solitons repel each other in a magneto-optic structure

15:30
TuL4
(Invited)

Spatial and Temporal Instabilities of Light Fields in Cavity-Free Optical Bistable Systems

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Diffraction instability appearence is discussed under the propagation of laser beam in optical bistable absorption system. A formation of high absorption kink near the back section of nonlinear medium ("reverse" kink) is predicted. Evolution of multy-domain structures caused by diffraction of light beam is studied. Hence the diffraction of light beam changes significantly the spatio-temporal evolution of high absorption domains

The new chaos formation scenario in problems of optical dynamics is discorvered. It consists of additive increasing of spatial harmonics frequencies of temperature and concentration of free charge-carrier particles of semiconductor under the condition of an absorption optical bistability realization with allowance for temperature dependence of free charge-carrier particle lifetime.

It was shown a principal possibility of realization of optical bistability due to interaction of counter propagating waves one of them is product of reflaction of other from a plane mirror having a hole at its axis and displaced near the back face of crystall. Oscillation regimes of output light power were obtained in numerical simulations.

Periodical self-switching from one stable state to another stable state was discovered in an absorbtion optical bistability based on semiconductor under the condition of action of short light pulse which induced a nonequilibrium distribution of electric field.

It is analysed an absorption optical bistability scheme with lateral optical feedback. It is shown that there is the possibility of existence of OB due to reflection coefficient of feedback mirror.

16:00
TuL5

Parametric Solitons

David R. Andersen[1], *Paul B. Lundquist*[2], *and Yuri S. Kivshar*[3]

January 30, 1998

We develop a general framework for understanding the characteristics of multi-frequency (multi-color) parametric solitons [1] of the parametric nonlinear Helmholtz equation. We identify two special classes of such solitons: *cascaded parametric solitons*, where the optical energy is shared between several harmonically-related frequency bands; and *isolated-bandwidth solitons*, where all of the optical energy is localized within a single frequency band. As an example, we consider the case of a five-color isolated-bandwidth parametric soliton in a Kerr medium.

In this talk, we will describe the nature of the (conservative) Hamiltonian system that gives rise to these various types of parametric solitons. At this point, we leave the most general case as intractable. However, as symmetries in the Hamiltonian arise due to the characteristics of the nonlinear medium under study (*e.g.* a specific order of nonlinearity or a specific dispersion-limited band of frequencies to be considered), significant progress can be made in understanding the general characteristics of these spatially *localized multi-frequency* waves. For example, we demonstrate in this paper that in the case of the band-limited third-order nonlinear response, it is possible to reduce all n-color soliton solutions to a two-parameter family. This remarkable result is independent of the number of colors n being considered.

Here, we focus only on the existence of the parametric solitons themselves, omitting detailed consideration of the stability characteristics of these novel solitons; this issue is more involved for multi-component parametric solitons than for the scalar one-component fields. Analysis of the stability of these localized waves is currently in-progress, but has not yet been completed.

Reference

1. P. B. Lundquist, D. R. Andersen, and Y. S. Kivshar, "Parametric Solitons," *to appear in Optical and Quantum Electronics*, special issue on Spatial Solitons (1998).

16:45-18:30 **RED HALL**

TuM - Fundamental Aspects of Laser-Matter Interaction IV

Presider: *P.P. Pashinin, General Physics Inst., Russia*

16:45 TuM1 (Invited)

Main physical processes in laser isotope separation of ytterbium-168 in weight amounts

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The GPI and LAD Ltd development of the ytterbium-168 separation in weight amounts1,2 have qualitatively advanced an AVLIS method. Isotope separation by AVLIS method not as a demonstration but on a commercial level was carried out for the first time. It has required the decision of a lot of technological problems, which do not arise as at laboratory demonstration of effect, and in research, not oriented directly to profitable production of an enriched isotope.The process of laser isotope separation of Yb have been studied theoretically, with numerical simulation and experimentally. Installation to produce highly enriched 168Yb in industrial scales was created. Contents of 168Yb in laser produced plasma was reached 80 - 95 %, in washing liquid - up to 32 %. The production rate of he enriched ytterbium was 3_6 mg/hour.In the report the theoretical problems are affected, which solution has allowed to achieve success. Here enter: problems of a selective photo-ionization actual and laser bundles; use of a resonator for a raise of effectiveness of a photo-ionization; simulation of extraction process; simulation of process of shaping atomic vapor. The scheme of the created installations on Yb - 168 selection in weight amounts are discussed.

REFERENCES

1. Derzhiev V.I., Kuznetsov V.A., Mikhal_tsov L.A., Mushta V.M., Sapozhkov A.Yu., Tkachev A.N., Chaushanskii S.A., Yakovlenko S.I.. Kvantovaya Electron. (Moscow) 23, 771 (1996) [Quant. Electron. 26, 751 (1996)]
2. Derzhiev V.I, Kuznetsov V.A., Mikhal_tsov L.A., Mushta V.M., Sapozhkov A.Yu., Tkachev A.N., Chaushanskii S.A., Yakovlenko S.I. Proceedings of the Int. Conf. on Lasers_96 (Portland Or, December 2-6, 1996), STS Press, McLean, VA, 1997, p. 441-448

17:15 TuM2 (Invited)

MAGNETOINDUCED AND ELECTROINDUCED SECOND HARMONIC GENERATION IN NANOSTRUCTURES AND LOW-DIMENSIONAL SYSTEMS

O.A. Aktsipetrov

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In this paper we survey the results of our recent and previous studies of magnetization induced and electroinduced effects in second harmonic generation (SHG) from magnetic and semiconductor nanostructures.

Among the merits of the SHG probe of low-dimensional structures its unique sensitivity to the properties of very thin films (down to monolayers), surfaces, and buried interfaces has been proved. This is based on the high sensitivity of the quadratic nonlinear optical response to the break down of inversion symmetry. Three basic mechanisms of inversion symmetry break down in nanostructures and at surfaces, interfaces of centrosymmetric materials are discussed: the mechanism of the surface dipole $\chi^{(2)S}$ which stems from the discontinuity of crystalline structure; the other mechanism of the bulk dipole $\chi^{(2)B}$ in metallic nanocrystals, stemming from the lack of inversion symmetry in nanocrystals with noncentrosymmetric shape and the third mechanism of inversion symmetry break down due to the DC-electric field application. The latter mechanism describes the enhanced DC-electric field induced SHG (EFISH) in Si-SiO_2 multiple quantum wells Si-based MOS structures which was observed in our experiments.

Another domain of nonlinear optics of low-dimensional systems appears as the break down of the structural inversion symmetry is combined with the break down of time reversal symmetry due to the magnetization of a magnetic material. The magnetoinduced SHG (MSHG), in particular, nonlinear-optical Faraday effect and nonlinear-optical magnetic Kerr effect were observed experimentally for the first time ten years ago in [1]. In this paper MSHG effects are studied in Co nanocrystals and Gd-containing Langmuir-Blodgett monolayers. In principle, magnetic noncentrosymmetric nanoparticles and thin films possess at least four dipole nonlinear susceptibilities contributing to the quadratic polarization and, as a consequence, to the second harmonic (SH) field. These are surface and bulk nonmagnetic structural (crystallographic) susceptibilities and surface and bulk magnetic susceptibilities. As the surface and bulk nonmagnetic and magnetoinduced nonlinear polarizations related to these susceptibilities are excited simultaneously, their interference enhances the appearance of the (intrinsically small) magnetization induced nonlinear optical effects. The role of the surface-bulk and bulk-bulk cross-terms in the appearance of MSHG effects is discussed.

1. O.A. Aktsipetrov, O.V. Braginskii, D.A. Esikov, Proccedings of ICONO-13 (Minsk, USSR, 1988) v. 2, p. 142 (1988); O.A. Aktsipetrov, O.V. Braginskii, D.A. Esikov, Sov. J. Quantum Electron. 20, 259 (1990).

17:45
TuM3
(Invited)

Nonlinear Optics of Magnetic Crystals

Th. Rasing, A. Kirilyuk, V.N. Gridnev, V.V. Pavlov, and R.V. Pisarev

Nonlinear optics of magnetic crystals is a very recent field that exhibits a number of unusual optical phenomena. Using the electric dipole approximation we discuss the crystallographic and magnetization-induced nonlinear susceptibilities that coexist in magnetic crystals. It is theinterference between the nonlinear optical waves of different origin that is the source of novel magneto-optical effects, such as a transversaleffect at normal incidence and linear in **M**[1], dichroism for linearly polarized light in longitudinal geometry, etc., that have no equivalent in linear optics. A very intriguing observation is that in the nonlinear magnetic circular dichroism (MCD), the equivalence that exists in linear optics between a change in light helicity and magnetization direction, is broken for the nonlinear case. This surprising fact can simply be related to the different symmetry properties of the corresponding tensor elements.As a model system for experimental studies we took thinepitaxial films of magnetic garnets grown on substrates with different crystallographic orientations. The second harmonic generation (SHG)from these sampleswas studied in the spectral range of 0.71-0.84 μm. The unambiguous separation of the crystallographic and magnetic contributions to the net SHG signal could be demonstrated with the help of rotational anisotropy experiments in an applied magnetic field. These experiments were done in both transverse and longitudinal geometries. The experimental data on the SHG rotational anisotropy perfectly confirm the predicted effects. The corresponding crystallographic and magnetic components are of comparable amplitude, with the magnetic ones vanishing above the Curie point. These novel magneto-optical effects also open new possibilities for the nonlinear magneto-optical microscopy, as was recently demostrated by us [2]

1 V. V. Pavlov, R. V. Pisarev, A. Kirilyuk, and Th.\ Rasing, Phys.\ Rev.\ Lett.\ **78**, 2004 (1997).\\
2 V. Kirilyuk, A. Kirilyuk, and Th.\ Rasing, Appl.\ Phys.\ Lett.\ **70**, 2306 (1997).

18:15
TuM4

OPTICAL BISTABLE RESPONSE OF AN OPEN LINEAR FRENKEL CHAIN: EXCITON-EXCITON ANNIHILATION AND BOUNDARY EFFECTS

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During the nineties, one-dimensional substances such as J-aggregates of poly-methine dyes and conjugated polymers attract the attention of investigators due to the extraordinary features of their photo-response mainly caused by the collective (excitonic) character of the excitations. In the last time, a possibility to observe a bistable behaviour in optical response of linear aggregates [1 – 3] are discussed. The effect originates from the dynamical resonance frequency shift with the population of the system and consists of a sudden switching of the population from a low level to a higher one with increasing the pump intensity. The shift mentioned reflects, in fact, the *fermionic character of the excitonic eigenstates.*

In this contribution, the one-molecular density matrix approach is used to analyze the nolinear optical response of an open linear Frenkel chain in the presence of the exciton-exciton annihilation. The mean-field approximation predicts the possibility to get a bistable behaviour in the response, even in the case of a large magnitude of the annihilation constant comparable to the *dipole-dipole interaction of monomers* composing the chain.

The numerical study based on the exact set of equations for the one-molecule density matrix shows that, in the absence of the annihilitation process, a bistable behaviour predicted is generally failed due to the spatial ingomogeneity of the density matrices of monomers. Growing with time, this ingomogeneity finally provokes the transition of the system from the the lower branch of population (becoming thus unstable) to the upper stable branch. So that one can say that the bistable behavior can be observable only over a certain interval of time after the external field is switched on.

The exciton-exciton annihilation, the rate of which rises with population, faces the enormous increase of population at a certain region of the chain and stabilizes *it in such a way providing conditions for bistability to be revealed.*

[1] V. V. Gusev, Adv. Mater. Opt. Electr. **1**, 235 (1992).
[2] V. Malyshev and P. Moreno, Phys. Rev. A **53** 416 (1996).
[3] V. A. Malyshev, H. Glaeske and K.-H. Feller, Opt. Commun. **140**, 83 (1997).

18:30
TuM5
(Invited)

Plasma Interaction with Intense Laser Fields with Distributed Parameters

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Summary

We address theoretically the issue of a dense, classical two-component plasma interacting with a high frequency intense laser field, with the aim of a) establishing how the field modified plasma characteristics depend on real laser properties, and b) investigating nonlinear laser-plasma processes such as, for instance, high-order harmonic generation. Among the laser properties, we plan to take into consideration the cases when the laser system exhibits statistically and deterministically distributed parameters. Examples are multimode laser systems with given statistical properties and intense laser systems with given space-time inhomogeneities, due to pulsed operation and focusing. To the latter case belong ultrashort-pulsed laser systems as well. Among the plasma properties to be investigated, a key role is played by the electron velocity distribution function for its importance in characterizing the overall plasma behavior. As a rule the reported results will be compared with those obtained in equivalent conditions but with an ideal laser system having well fixed parameters. As far as possible, computational methods and analytical procedures will be used in a crossed way.

16:45-18:30 **GREEN HALL**

TuN - Ultrafast Phenomena IV

Presider: *V.V. Shuvalov, M.V.Lomonosov Moscow State Univ., Russia*

16:45
TuN1
(Invited)

Femtosecond Dynamics of Semiconductor Microcavity Polaritons

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Dynamics of semiconductor microcavity modes in ZnS-Ni structure was investigated by femtosecond pump-supercontinuum probe spectroscopy in wide spectral region 1.6 - 3.2 eV. The change of reflectivity of the ZnS thin films (of 0.29 mkm, 1.08 mkm and 1.17 mkm) on thick Ni film on quartz substrate was monitored. Two different pumping photon energies hw_pu1 = 2.75 eV and hw_pu2 = 5.5 eV were used for the excitation of the microcavity and produced different photoresponse spectra. The first pumping energy (2.75 eV) is lower than the energy gap of ZnS (3.7 eV) and the powerful laser pulse excites electrons of metal (*i.e.* boundary of the microcavity) and of ZnS layer (mainly by two-photon absorption). Nonequilibrium carriers of metal penetrate through Schottky electron barrier into the semiconductor. For the second pumping energy (5.5 eV) the pumping pulse is practically totally absorbed in thin surface ZnS layer of 40nm in thickness and creates nonhomogeneous hot carriers distribution in semiconductor. The differenses in the processes of carrier excitation are responsible for the differenses in the changes of dielectric functions of ZnS and Ni and for the differenses in the change of cavity modes.

17:15
TuN2
(Invited)

Femtosecond Carrier Dynamics in Semiconductor Nanocrys

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Due to quantum confinement and a large surface-to-volume ratio, carrier e ergy relaxation and recombination dynamics in semiconductor nanocrystals (NC are significantly different from those in bulk materials [1]. We report femtosecon (fs) studies of energy relaxation and trapping dynamics in three types of NC sy tems: semiconductor NC/glass composites made by high temperature precipitatio ion-implanted NCs, and colloidal NCs. Comparison of ultrafast data for differen samples allows us to separate effects being intrinsic to quantum dots from thos related to lattice imperfections and interface properties.

Chirp-free transient absorption (TA) [2] is applied to directly measure the popu lation dynamics of the lowest (1S) and the first excited (1P) electron states in CdS NCs of different radii, with 1S-1P energy separation up to 16 longitudinal optica phonon energies. Instead of the drastic reduction of the energy relaxation rate ex pected due to a phonon bottleneck [3], we observe a fast sub-ps 1P-to-1S relaxation with the rate enhanced in NCs of smaller radius. This indicates the opening of ne confinement-enhanced relaxation channels which dominate any phonon bottleneck effects.

In contrast to the *initial energy relaxation, 1S-electron decay is strongly* sampl dependent. In colloidal samples with well passivated surfaces, the depopulation o the 1S state is dominated by radiative recombination, whereas in glass samples mad by both high-temperature precipitation and ion implantation, the 1S electrons relax via efficient ps trapping at deep defect states, strongly enhanced in NCs of smaller radius. Application of fs up-conversion photoluminescence and TA allows us to separate the electron and hole relaxation paths.

The studies of pump-dependent TA indicate a change in carrier relaxation channels at high pump levels. This change is explained in terms of Auger-assisted carrier trapping at interface states, leading to efficient charge separation, with the associated generation of local electric fields [4]. Using NCs in different types of matrices, we study the effect of the height of the confinement barrier on the efficiency of the Auger-assisted surface trapping.

We thank M. Bawendi and W. White for providing high-quality NC samples.

[1] V. Klimov, in *Handbook on Nanostructured Materials and Nanotechnology*, edited by H. Nalwa (to be published by Academic Press, 1998).
[2] V. Klimov and D. McBranch, Opt. Lett. **23**, (1998).
[3] A. L. Efros, V. A. Kharchenko, and M. Rosen, Solid State Commun. **93**, 281 (1995).
[4] V. Klimov and D. McBranch, *Phys. Rev.* B **55**, 13173 (1997).

VIBRATIONAL DYNAMICS OF THE MOLECULAR IODINE BY CHIRPED FEMTOSECOND LIGHT PULSES: EXPERIMENT AND THEORY.

17:45 TuN3

V.V.Lozovoy, S.A.Antipin, F.E.Gostev, A.A.Titov, D.G.Tovbin, O.M.Sarkisov, A.S.Vetchinkin, S.Ya.Umanskii.
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Vibrational dynamics of I_2 in the electronic state B was studied by the femtosecond "pump-probe" method with the use of chirped light pulses. Special method of femtosecond light pulses chirp control was developed for this purpose.

It was observed in agreement with [1] that chirping of the pump pulse influences significantly the dependence $W(\tau)$ of the intensity of the detected I_2 fluorescence on time delay τ between the pump and probe pulses. First time influence of the probe pulse chirp on the form of $W(\tau)$ was observed.

Numerical simulation of $W(\tau)$ was performed using an approach developed in [2] and measured spectral parameters of the pump and probe femtosecond pulses. Good agreement between theoretical and experimental curves was obtained. Simulation of $W(\tau)$ was supplemented by investigation of the pump pulse chirp influence on the dynamics of the formed by this pulse vibrational wave packet in the electronic B-state using Wigner-Husimi technique. This study showed that chirping effects the degree of initial localisation of this wave packet which manifests itself in the time of the first wave packet revival.

Results obtained witness principal possibility to control intramolecular dynamics by varying phase characteristics of the pump femtosecond light pulses. and the necessity to control chirp of the probe pulse for qualitative interpretation of experimental results.

1. B. Kohler, V. V. Yakovlev, J. Che et al , Phys. Rev. Lett. 74 (1995) 3360.
2. V.V.Lozovoi, O.M.Sarkisov and S.Ya.Umanskii, Chem. Phys Repts. 14 (1995) 1164.

Efficient narrow-band soft X-ray generation from femtosecond laser plasma by Nd-doped glass

18:00 TuN4

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X-ray generation from femtosecond laser produced plasma is attracting much attention from the various points of scientific interest as well as practical applications.(1,2)

This paper reports on efficient narrow-band soft X-ray generation from femtosecond laser plasma using Nd-doped glass targets for the first time. A 10Hz high power Ti:sapphire laser system is used as a light source. Pulse width and output energy are 120 fs and 100 mJ, respectively. The center wavelength is 790 nm. An extinction ratio is better than 10^6. The laser beam is divided into two beams with a 50 ns time difference to achieve the enhancement of soft X-ray generation by double pulse irradiation (3) and focussed onto glass targets with various Nd concentrations from 5 to 51 wt%. The pre and main pulse intensities used in the experiment were $5X10^{14}$ and $1X10^{16}$ W/cm^2, respectively. Typical soft X-ray spectra measured with a spectrograph are shown in Fig. 1. Nd concentration of the target is 44 wt%, which is the optimum value to obtain the highest intensity under the above experimental condition. Narrow-band soft X-ray at around 8 nm, emission from N-shell transition, with less than 1nm width is clearly observed. The measured photon number was about 10^{11} photon/(A· sr), and the energy conversion efficiency was about 1%. The temporal evolution of soft X-ray emission was also measured with a time-resolved spectrograph having a transmission grating with a 200 nm period and a X-ray streak camera. The temporal and spectral resolution were 3ps and 0.3 nm. Soft X-ray pulse duration of 350 ps at 8 nm was obtained, as shown in Figure 2. It is also observed that the center wavelength was slightly chirped during the expansion. The properties of spectral and intensity changes for the different Nd concentrations are also clarified. Ref.) 1) M. Murnane et al., Appl. Phys. B58, 261 (1994). 2) C. Rischel et al., Nature 390, p.490 (1997). 3) D. Kühlke et al., Appl. Phys. Lett. B50, 1785 (1989).

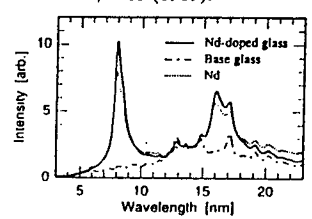

Fig. 1 Soft X-ray Spectra

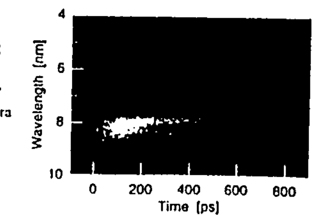

Fig. 2 Temporal evolution

18:15
TuN5

FEMTOSECOND DYNAMICS OF OFF-EQUILIBRIUM ELECTRONS IN METAL FILMS

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Ultrafast electron interactions are key processes in the fundamental and technological properties of metallic systems. With the advance of the femtosecond sources, these can now be directly investigated in the time domain on a time scale shorter than that of the internal thermalization of the electron gas, offering the unique possibility of investigating interactions of an off-equilibrium electron gas with its environment. Here we show experimentally and theoretically that the electron gas-lattice energy exchanges and the average electron scattering time, that involve elementary scattering processes faster than the electron gas thermalization time, are strongly altered during the early stages of the internal thermalization of a nonequilibrium electron gas.

Measurements were performed in a silver film using a 18fs pump-probe technique. The electron distribution is perturbed by free electron absorption of an infrared pulse and the induced changes of the optical properties are probed at the same wavelength. The results demonstrate acceleration of the energy losses of the electron gas to the lattice, a constant energy loss rate being eventually observed as the electron gas reaches internal thermalization, in agreement with numerical simulations. This behavior reflects a transient evolution from an individual to a collective electron-lattice type of coupling: redistribution by electron-electron scattering of the excess energy initially injected in a small number of electrons increases the number of electrons that can loose energy by emitting a phonon and thus the total energy losses. Similarly the average electron-electron scattering rate has been found to increase with time, reflecting

16:45-18:30 **BEIGE HALL**

TuO - Quantum and Atomic Optics IV

Presider: *I.I. Sobel'man, Lebedev Physical Inst., Russia*

16:45
TuO1
(Invited)

What Do We Know About Atomic Bubbles In Helium Crystals?

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It has been known for about a decade that foreign atoms immersed in *superfluid* ^{4}He form small cavities from which helium is expelled by virtue of the exchange interaction. In analogy to electron bubbles these entities have been called *atomic bubbles*. Due to the large zero point motions of the constituent atoms both *solid* and *superfluid* helium matrices can be described as weakly bound continuous media. It was thus to be expected that foreign atoms in *solid* ^{4}He would also form bubbles. Optical spectroscopic results have confirmed this hypothesis and have allowed to infer the size of the bubbles.

In recent years we have investigated cesium atoms in crystalline solid He matrices. The experimental technique is based on laser induced fluorescence and magnetic resonance with optical preparation and detection. We have measured extremely long (longitudinal and transverese) electronic spin relaxation times which indicate that the bubbles in that phase have an extremely high degree of spherical symmetry. In hexagonal He crystals we have observed several distinctive features, such as dipole forbidden transitions, zero-field magnetic resonance lines, small (field dependent) relaxation times. We interprete these features as being due to static quadrupolar deformations. The quantitative analysis of these results allows to infer the degree of deformation of the bubbles. Our recent comparison of the hyperfine structures in the cubic and hexagonal phases allows an alternative determination of the bubble deformations.

Besides *static* bubble deformations we have also studied *dynamic* deformations (oscillations). The structure of the hyperfine transition yields information on breathing mode (k=0) oscillations, while magnetic field dependent perturbations of the Lande g-factors allow to determine the amplitudes of quadrupolar (k=2) bubble oscillations.

Details of these results will be presented at the conference.

17:15
TuO2
(Invited)

PHOTON NUMBER TOMOGRAPHY, OPTICAL TOMOGRAPHY, SYMPLECTIC TOMOGRAPHY, AND QUANTUM STATE MEASUREMENTS

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Review of different tomographic methods of measuring quantum states is given.

Optical tomorgaphy [1, 2] based on Radon transform, symplectic tomography [3] using Fourier transform, and photon number tomography [4], in which discrete photon number is measured, are compared and relations between probability distributions determining quantum states in all three types of tomography are connected by some invertable integral transforms.

The reconstruction of Wigner function of quantum states in the three types og tomographics is presented.

A formulation of the evolution of quantum states in terms of probability distributions (instead of wave function and density matrix) is given. The Fokker-Planck-type equation which determines the quantum-state evolution in the new formulation of quantum mechanics is considered in for a damped linear oscillator and for an anharmonic oscillator.

References

[1] J. Bertrand and P. Bertrand, *Found. Phys.* **17**, 397 (1987).

[2] K. Vogel and H. Risken, *Phys. Rev.* A **40**, 2847 (1989).

[3] S. Mancini, V.I. Man'ko, and P. Tombesi, *Quantum Semiclass. Opt.* **7**, 615 (1995).

[4] S. Mancini, V.I. Man'ko, and P. Tombesi, *Europhys. Lett.* **37**, 79 (1997).

17:45
TuO3
(Invited)

HIGH-Q MICROSPHERE RESONATORS IN SUPERFLUID HELIUM: TOWARDS MICROLASER AND CAVITY QED WITH "ZERO-PHONON LINES"

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Microspheres with high-Q whispering-gallery modes (WGMs), besides technical applications, are attractive for quantum nondemolition (QND) measurement and cavity QED [1]. With mode volume of hundreds μm^3, microsecond photon storage times with $Q > 10^9$ are much longer than Rabi period of an atomic unit dipole coupled to the vacuum field in a mode. Feasibility of strong coupling experiments is however constrained by thermal effects: 1)thermal bistability of WGM [2] and 2)transition broadening a)by doppler or transit-time effects -- dictating laser cooling in experiments with free atoms or ions, or b)by phonon-induced dephasing -- dictating cooling of solid host matrix to approach natural linewidth in embedded doping spieces ("zero-phonon lines" ZPL [3]).

We developed cryogenic setup to immerse microspheres in superfluid helium at 2K and were able to keep routinely $Q = (0.3 - 1)\times10^9$ in 50-100µm silica spheres while in superfluid He. We also observed suppression of thermal bistability due to reduced thermo-refractive constant of silica and efficient heat removal from the WGM volume by superfluid He. The remaining intrinsic Kerr nonlinearity of silica produced dispersive optical bistability of WGM with threshold power ≈ 10 µW (sphere diameter 50µm; loaded $Q = 2\times10^8$). The fitted nonlinear refraction index from the bistability curves $(n_2)_{fit} \approx +1.2\times10^{-16}$ cm²/W was in agreement with reported value $n_2 = +2.5\times10^{-16}$ cm²/W, with account of experimental uncertainties.

Suppression of thermal nonlinearity makes silica microspheres suitable [1] for QND energy measurement via mode cross-phase modulation. Our experiments are also first step towards 1)realization of thresholdless microlaser [4] with only few excited ions on the basis of Nd-doped silica microsphere [5] and 2)cavity QED with single molecule [6] embedded in a host microcrystal in evanescent field of WGM. A promising candidate — dibenzoterrylene in naphtalene — exhibits intense ZPL (oscillator strength corresponding to a radiative lifetime ≈ 60ns) with homogeneous linewidth about 30MHz at 1K, 757nm, allowing strong coupling regime with most confined WGMs in 50µm sphere.

[1] V.B.Braginsky, M.L.Gorodetsky, V.S.Ilchenko, Phys.Lett.A137, 393(1989); L.Collot, V.Lefèvre-Seguin, M.Brune, J.-M.Raimond, S.Haroche, Europhys.Lett 23, 327 (1993); H.Mabuchi, H.J.Kimble, Opt.Lett. 19, 749 (1994); D.W.Vernooy, A.Furusawa, N.Ph Georgiades, V.S.Ilchenko, H.J.Kimble, Phys.Rev.A (1998) (in press)
[2] V.S.Ilchenko, M.L.Gorodetsky, Laser Physics 2, 1004 (1992)
[3] W.E.Moerner, L.Kador, Phys.Rev.Lett 62, 2535 (1989); M.Oritt, J.Bernard, Phys Rev Lett. 65, 2716 (1990)
[4] Y.Yamamoto, R.E.Slusher, Physics Today 46, 66 (1993)
[5] V.Sandoghdar, F.Treussart, J.Hare, V.Lefevre-Seguin, J.-M.Raimond, S.Haroche, Phys Rev A54, R1777 (1996)
[6] D.J.Norris, M.Kuwata-Gonokami, W.E.Moerner, Appl.Phys.Lett. 71, 297 (1997)

18:15
TuO4

QUANTUM CRYPTOGRAPHY WITH POLARIZED ENTANGLED PHOTONS

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We report on the experimental realization of new scheme for quantum cryptography which is based on the use of strongly unbalanced quantum intensity interferometer. This technique utilizes a double entangled EPR quantum states generated in the nonlinear process of type-II spontaneous parametric down conversion (SPDC).

There are two major techniques in quantum cryptography which historically appeared almost simultaneously. One uses the quantum features of single photon states in non-orthogonal bases.[1] The other one is based on the quantum nonlocal character of two-photon entangled EPR states. The applicability of the latter one was strongly limited because of low visibility and pore stability of the system which requires synchronous manipulation of two well separated in space Mach-Zehnder interferometers.[2] We attempt to resolve this problem with the help of additional physical properties of entangled states generated in type-II SPDC.[3] In the Hong-Ou-Mandel[4,5] correlation intensity interferometer, quantum interference is observed when the photons of a spontaneous parametric down conversion pair simultaneously impinge upon the output beamsplitter. We report on an experiment in which quantum interference effect is observed even though the photons of two orthogonal polarizations generated in a type-II SPDC do not arrive at the beamsplitter at the same time. The indistinguishability of the different two-photon Feynmann-amplitudes leading to a coincidence detection is restored by introducing a postponed compensation delay line nonsymmetrically only in the one output port of a beamsplitter. The contrast of restored two-photon quantum interference picture has been observed to be 99%. This type of postponed compensation highlights the non-classical nature of the two-photon state produced in SPDC, which can not simply be thought of as two single photons.

The nonsymmetric introduction of postponed compensation delay in our strongly unbalanced polarization intensity interferometer makes this technique suitable for practical quantum cryptography applications. The quantum state preparation is performed in the transmitting area (Alice). The receiver (Bob) will keep a single photon counting detector and a polarization analyzer-modulator only. The high contrast and stability of quantum interference demonstrated in our experiment experiment illustrates the strong immunity of this technique to active probing by an eavesdropper and promises to bring the performance to the level of the best single-photon polarization techniques.

[1] C.H.Bennet, Phys.Rev.Lett., 68, 3121 (1992).
[2]A.K.Ekert, J.G.Rarity, P.Tapster, and G.M.Palma, Phys.Rev.Lett., 69, 1293 (1992); J.D.Franson, Phys.Rev., A44, 4552 (1991).
[3] T.B.Pittman, Y.H.Shih, A.V.Sergienko, and M.H.Rubin,Phys.Rev.,A51, 4337 (1995).
[4]C.K.Hong, Z.Y.Ou, and L.Mandel, Phys.Rev.Lett., 59, 2044 (1987).
[5] P.G.Kwiat, A.M.Steinberg, and R.Y.Chiao, Phys.Rev., A45, 7729 (1992).

18:30
TuO5

Resonance fluorescence exited by a macroscopic superposition in a feedback loop. D.B.Horoshko and S.Ya.Kilin Institute of Physics, National Academy of Sciences of Belarus F.Skarina Ave. 70, Minsk 220072 Belarus

In the modern quantum optics resonance interaction of a single atom with quantized field is widely used for atom and field state manipulation, thus providing growing interest to considering resonance fluorescence initiated by nonclassical states of field. Recently the resonance interaction of a two-level atom with a macroscopic superposition of two coherent states (Schrödinger cat like state) in a high-Q cavity has been studied [1]. However, this analysis was restricted only to short times at the initial stage of interaction, as the Schrödinger cat state is rapidly destructed by any interaction with environment. We propose a scheme which escapes the problem by monitoring and continuous correcting the field state via electro-optical feedback loop. In our scheme the intracavity field, initially prepared in a Yurke-Stoler superposition state $|\alpha_+\rangle = (|\alpha\rangle + i\,|-\alpha\rangle)/\sqrt{2}$, decays through one of the cavity mirrors with the rate κ and illuminates a two-level atom placed outside the cavity. To protect the driving field from decoherence, all outgoing photons both scattered from atom and not scattered are collected on high efficiency detectors and the photocurrents control a phase modulator placed *inside the cavity, shifting the cavity field phase by* π after each photocount. Such a feedback is shown to preserve the quantum coherence of the intracavity field [2]. We derive a master equation for the evolution of the atom-field system and solve it analytically for the initial condition $|\psi(0)\rangle = |\alpha_+\rangle\,|-\rangle$,where $|-\rangle$ denotes the lower atomic state. This solution, contrary to the solution of Bloch equations, does not contain Rabi oscillations of atom dipole moment and inversion. The latter two grow exponentially on the initial stage of interaction till they reach the stationary state value, determined by the field amplitude $\alpha(t)$ assumed to be varying slowly ($\kappa << \Gamma, \kappa\,|\alpha|^2$, where 2Γ is the spontaneous decay rate of the atom). The stationary state value of the average dipole moment can be compared to that for the case of coherent excitation:

$$\langle\sigma_-\rangle_{YS} = \frac{ig\alpha}{\Gamma + 2\kappa\,|\alpha|^2}e^{-2|\alpha|^2} \qquad \langle\sigma_-\rangle_{Coh} = \frac{ig\alpha}{\Gamma + 2\,(g^2/\Gamma)\,|\alpha|^2}$$

where g is the atom-field coupling constant. The suppression of Rabi oscillations in the dynamics of atomic populations can be seen from the second-order correlation function of scattered light intensity $\langle\sigma_+\sigma_+(t)\sigma_-(t)\sigma_-\rangle$, which is available from the records of the fluorescent light detectors. This correlator also reaches the steady state value without oscillations in the timescale Γ^{-1}. [1] S.Ya.Kilin and V.N.Shatokhin, Phys.Rev.Lett. **76**, 1051(1996). [2] D.B.Horoshko and S.Ya.Kilin, Phys.Rev.Lett. **78**, 840(1997).

BLUE HALL

16:45-18:30

TuP - Nonlinear Optical Phenomena IV

Presider: *J. Zyss, Ecole Normale Superieure, France*

16:45
TuP1
(Invited)

OPTICAL VORTICES IN NONLINEAR MEDIA: ORIGIN, DIRECT AND REVERSED EVOLUTION

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SUMMARY

Optical vortices (OV), or phase singularities of wavefront, can appear spontaneously in a beam smooth wavefront by its topological transformation after a Gaussian lens[1]. Such effect was observed firstly *inside* a Kerr-like defocusing medium due to self-induced Gaussian-like nonlinear waveguide. Previously OV birth was observed in free space after self-action of a laser beam in a nonlinear medium.

Gaussian beam of cw Ar^{+} laser ($P \leq 160$ mW) was focused in the middle of 250 mm cell filled with slightly absorbing ($\alpha \approx 0.3$ cm^{-1}) methanol dye solution. Up to three equally organized quadruples of alternating sign single-charged large-core OV was observed on the beam wings for low input power (< 50 mW).

The high-input power (>100 mW) provides dramatic changes in the structure of self-induced waveguide: an elliptical caustic in beam cross-section develops due to nonlinear perturbations of propagating wavefront in according with catastrophe theory[2]. Two new quasi-spherical interference pattern systems develop. Their intersection in the beam center initiate appearance of two close (80 μm distance) dark soliton stripes which break due to Kelvin-Helmholz instability[3]. As a result one close quadruple of OV appears on their ends in the beam interior. The rapid intensity changes in cross-section of OV core caused nonlinear formation of small-core (50 μm) soliton-like vortex channels in the laser beam interior in high input beam power regime. The experimental results are in good agreement with theory prediction.

1. L.V.Kreminskaya, M.S.Soskin, A.I.Khizhnyak, Opt. Commun. 14591998) 377.
2. V.I Arnold,Catastrophe Theory, Moscow, "Nauka", 1990 (in Russian).
3. C.T.Low and G.A.Swartzlander, Jr., Opt. Lett., 18 (1993) 586.

17:15
TuP2

FILAMENTATION OF ULTRASHORT LASER PULSES IN AIR

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Long-range filamentation (10 ÷ 100 m) of powerful (10 ÷ 100 GW) femtosecond laser pulses propagating through air has been recently reported [1-4]. The filament in air is generally accompanied by the conical emission which appears on a screen as a concentric rainbow with colors ranging outwardly from red to green [2,4]. The quantitative characteristic of the filament, the filament energy, was measured in [3] and was found to vary nonmonotonically with distance [3]. Filamentation was simulated using 2D+time Schrodinger equation with Kerr and ionization nonlinear terms. Numerical solution is in good agreement with the experiment [4].

Filament can be created because of self-focusing induced by the electronic Kerr nonlinearity of air. Observation of filamentation in air is possible only with powerful femtosecond pulses since longer pulses self-focusing is suppressed by lower threshold phenomena with longer time response (for example, phenomena cascade ionization and breakdown for nanosecond pulses, heat defocusing for millisecond pulses.). High intensities, which are achieved in the course of self-focusing, cause multiphoton ionization of the air. The ionization nonlinearity crucially affects the pulse propagation. Self-focusing due to Kerr nonlinearity and nonlinear defocusing due to ionization are two main effects that govern the filamentation.

Filamentation can be explained on the basis of the moving focus model extended to femtosecond pulse propagation in the medium with the electronic Kerr nonlinearity and ionization. The central slice of the pulse focuses closest to the input plane. With further propagation self-focus shifts towards the pulse front. What we see as a filament is, in fact, a succession of these self-foci. In contrast to the classical moving focus picture, in the case of filamentation in air the trailing part of the pulse (i.e. the part beyond the self-focus) breaks up into rings due to the defocusing in the plasma produced by the front of the pulse. These rings can diverge and contract. As a result, the filament energy changes nonmonotonically with distance. The conical emission occurring during the filamentation is due to spatio-temporal self-phase modulation, which originates from large gradient of the refractive index in the vicinity of the self-focus.

References

1.A. Braun et al., Opt.Lett., 20, 73 (1995).
2. E. T. J. Nibbering et al., Opt.Lett, 21, 62, (1996).
3.A. Brodeur et al., Opt.Lett, 22, 304 (1997).
4. O.G. Kosareva et al., Opt.Lett, 22, 1332 (1997).

17:30
TuP3

QUASI-ROTATIONAL WIDELY RANGING SPECTRUM GENERATION AT SELF-FOCUSING OF PICOSECOND PULSES IN HIGH PRESSURE HYDROGEN

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Waveguides or channels in gases can increase laser-gases interaction lengths and improve output radiation modal structure. In this report, coherent optical radiation with quite smooth beam profiles and quasi-rotational spectral structure ranging from the IR to the UV was generated due to vibrational and rotational stimulated Raman scattering and parametric processes in gaseous hydrogen at pressures of up to 100 atm.

1.06-μm linearly polarized pulses of 30-ps duration and of up to 40-mJ energy were focused into a cell filled with hydrogen. The luminous channel was formed due to self-focusing at the high enough values of the pump pulse energy and pressure. The energies of different spectral lines in the visible and the UV measured by diffraction grating and pyroelectric detector are shown on Fig.1. The energy of each spectral line in the green region was on the level of 10 μJ.

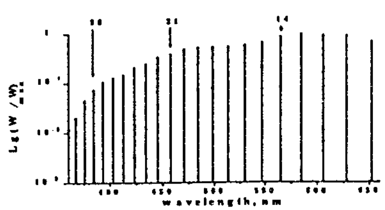

Fig.1. Energy of the spectral lines in the visible and the UV measured by diffraction grating and pyroelectric detector. The spectral lines are enumerated from the pump.

At hydrogen pressures >60 atm the individual spectral lines consisted of one or two cascaded rotational-vibrational components. Given above picture was observed when pump pulses were focused into the cell filled with hydrogen by lenses with focusing length 25-35 cm. When focusing length was increased to 50 cm and more character of the output radiation was drastically changed: the output radiation took the form of rings, corresponding to generation of cascaded vibrational lines.

17:45
TuP4

MULTICOMPONENT PHOTOREFRACTIVE SOLITONS

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Vorob'evy Gory, Moscow 119899, Russia

A new class of solitonlike solutions of the problem of nonlinear wave propagation through a photorefractive crystal[1] (PRC) with drift nonlinearity will be described in this paper. Solutions of this type can be considered as multicomponent spatial solitons, combined by two or more mutually incoherent self-consistent components bonded by cross-modulation coupling[2]. The components can be as of periodical as of spatially-localized character. The light field spatial distributions look like zero and higher order modes of their common nonlinear waveguide formed in PRC due to its nonlinearity. It will be shown that such multicomponent solitons are stable on distances of several diffraction lengths and their spatial structure is robust to collisions and appreciable (more than 10% in intensity) stochastic perturbations of the intensity distributions. Because of PRC nonlinearity saturation, parameters of all the soliton components (their amplitudes and widths) change quasi-periodically as the soliton propagates. In this case, the components do not exchange by the energy while a small fraction of the energy is emitted on few diffraction lengths. We are going to discuss also a possibility of excitation of stable solitonlike multielectron states[3] in conjugated polymers, ferromagnetics, and superconductors. These states could correspond to some mutually incoherent and self-consistent wave packets composed by electronic wave functions and propagating along conjugated chains or prominent atomic planes.

1. M. Segev et al., Phys. Rev. Lett. 73, 3211 (1994).
2. V. Kutuzov et al., Cross-modulation coupling of incoherent soliton modes in photorefractive crystals, Phys. Rev. B, 57 (April 1998, to be published).
3. A.S. Davydov, Physica Status Solidi B 146, 619 (1988).

18:00
TuP5

Non-Linear Magneto-Optic -- Spinwave Interactions in Ferromagnetic Waveguides

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Yttrium-Iron-Garnet thin ferromagnetic films currently found various applications. They possess a good quality suitable for both microwave and optic waves applications. First of all, these films with the thickness in few (or tens) of microns and lateral dimensions in one or even few centimeters possess properties of a ferromagnetic medium at the frequency ranging from 1 to 20 GHz. This frequency range is intensively studied due to possibility to excite and investigate traveling magnetostatic spin waves (MSW). In the optical infrared wavelength range between 1.1 and 6 μm YIG films find an application due to strong efficiency of magneto-optic interactions. The most interesting applications can be achieved when both microwave and light waves propagate simultaneously in such films. The possibility of such a film to support the waves is used for effective magneto-optic Bragg interaction between these waves. Frequencies and wave numbers of MSW are usually much smaller than the respective values for optic waves. Under the special relation between the wave numbers of the incident and diffracted light modes and the MSW wavenumber, the anisotropic Bragg diffraction of light can be quite essential.

In the present paper we report the results of our recent research in the field of non-linear interactions between light and spin waves in ferromagnetic films. Such interesting and important effects as Bragg diffraction of light by a non-linear spin wave, bistability in optical modes conversion, spin wave pulse generation under non-linear electromagnetic waves interaction, light pulses compression, have been considered. The conversion efficiency of the optical modes due to magneto-optic spin waves interaction can be about 40 % at the MSW power level of about 1 W per unit width. At this power level spin waves become strongly non-linear and this causes various undesirable effects. Among them appearance of new waves in the MSW spectrum; saturation of the MSW power; non-linear interaction between MSW and light most often can be met in an experiment. Since optical mode conversion is a linear effect and is supposed to be used in linear devices, all these non-linear effects accompanying traveling intensive MSW can be separated and used for important applications. The dependence of the conversion efficiency on the input MSW power makes it possible to control the phase-matching condition with the microwave power. Intensive non-linear MSW can be unstable to longitudinal or transverse instability. In the first case, it is modulation instability; in the second case, it is self-focusing of the MSW beam. The latter effect can be quite important in magneto-optic applications. Some of such possible application iare considered in the present work.

18:15
TuP6

NONLINEAR PHENOMENA IN SEMICONDUCTOR OPTICAL PLANAR AMPLIFIER

A.S.Logginov, full professor; A.G.Rzhanov, researcher; N.N.Marjin, student

M.V.Lomonosov Moscow State University, Physics Department, Chair of oscillations, address: Vorobjevy gory, Physics Department of Moscow State University, 119899, Moscow, Russia.

The model of static and dynamic behavior of an optical beam propagation in the active waveguide of a planar semiconductor optical amplifier was developed and realized as the computer software. The main goal of the present work is the developing of a computer tool for the optimization of powerful optical amplifier parameters with the aim to obtain the narrowest width of an output light pattern. The next goal is to investigate the nonlinear effects at sinusoidal and step-like bias current and input optical beam modulation. The computations with taking into account the processes of carriers and photons redistribution and nonlinear interaction between light, carriers and heat were done. The different values of values of waveguide parameter ρ (the ratio of real and imaginary parts variations of complex) and of bias current were tried.

The plane optical field distribution at ρ=-1.26 is transforming to the essentially nonuniform one at ρ=-4.4 (fig.1). Heat flow and dissipation processes changes near- and far-field due to the refractive index and local gain temperature dependencies ("local thermal lens").

We had investigated the three types of modulation: (1) For the pulse of input light the transient processes appeared to be consisting of the two parts: fast (0-20 ns), caused by redistribution of carriers in active layer, and slow (1-10 mks) caused by heat relaxation. (2) For the sinusoidal 100 MHz plus DC bias current at modulation depth of 20% and input optical power 10 mW (ρ=-4.4) the strong nonlinear output response takes place (fig.2). (3) For the sinusoidal input light beam modulation wide scale of input-output light phase shifts up to π at frequency 1 GHz were observed.

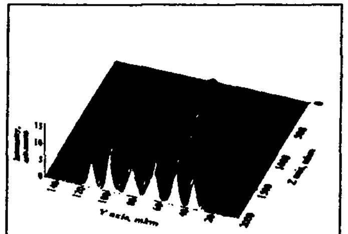

Fig.1 Intensity distribution in active layer with taking into account thermal effects, ρ= -4.4

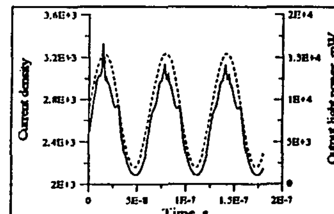

Fig.2 Bias current modulation. Current density (A/sm^2) - dashed line. Output power - solid line. ρ =-4.4; modulation frequency 100 MHz.

Poster Session

18:30-20:00 **RED HALL**

TuQ - Fundamental Aspects of Laser-Matter Interaction I

TuQ1

Investigation of Fine- Splitting in Zero-Magnetic Field of Stark Energy Levels of Pair, Quartet, and Sextet Nd^{3+} Optical Centers in the CaF_2 Laser Crystal by Selective Time-Resolved Laser Fluorescence Spectroscopy

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Time-resolved site-selective fluorescence laser spectroscopy of different types of optical centers which formed the M- and the N- absorption bands in the $CaF_2 Nd^{3+}$ doped crystal was performed at 1.6 and 4.2K. By analyzing the absorption and the $^4F_{3/2}$ fluorescence excitation spectra at the $^4I_{9/2}(1)\rightarrow{}^4G_{5/2}(1)$ inter-Stark transition as well as site-selective fluorescence spectra and kinetics decay at the $^4F_{3/2}(1)\rightarrow{}^4I_{9/2}(1)$ transition under selective laser excitation to the $^4G_{5/2}(1)$ Stark level it was found that so called the M and the N bands are inhomogeneous at concentrations less than 1% and formed by different types of Nd^{3+} clusters with different absorption and fluorescence excitation spectral lines as well as with different $^4F_{3/2}$ fluorescence lifetimes. The M-band is formed by different modifications of the pair (M-) centers with different distances between the Nd^{3+} ions and with modified local crystal field. The N-band is formed at least by quartet (N-) and partially by sextet Nd^{3+} centers. The weak absorption band between the M- and the N- bands is formed by numerous so called D(2a) types of centers, which we consider to be different types of trimer centers and sextets of (Nd_{Ca}^{3+}-F_i) structural units with increased distances between Nd^{3+} and F_i ions comparing to the N- and sextet ($6/6_1$) [J.Corish, et al. Phys.Rev.B, 25, 6425 (1982)] centers.

It was proved that the $^4G_{5/2}(1)$ Stark level in these centers is splitted into several sublevels due to strong coherent ion-ion interaction [T.T.Basiev, et al., J. of Lumin, in the press]. The values of fine splitting near 2.5, 3.5 are refined for pair and quartet optical centers, respectively. And that value of 6.5cm^{-1} was found for sextet optical centers.

TuQ2

LIGHT-INDUCED TRANSPORT OF ATOMS AND MOLECULES IN A BUFFER GAS OR CAPILLARY

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The light-induced transport phenomenon discussed below is brought about by inelastic collisions of excited atoms and molecules with atoms of a buffer gas or capillary walls. The energy of electronic excitation is transferred, in turn, to the translational degrees of freedom of active species. Hence, if the thermal capacity of the buffer gas is large enough, the active atoms become relatively "hot" in the illuminated area. As the inward and outward fluxes should be equal at steady state, the number density of active atoms in the illuminated area will be lowed. Although this phenomenon resembles the conventional thermal diffusion process, it differs from it in that inhomogeneous illumination heats the subsystem of active atoms only.

The phenomenon of light-induced transport was analyzed using Boltzmann equation for the partition function of the ground state and excited atoms. In the case of an admixture of light active atoms in a heavy quenching buffer gas an analytical solution is obtained for steady state. Contrary to the case of conventional thermal diffusion, the density gradient between dark and bright regions is due to the spatial variation of the mean free path as well as inhomogeneous heating.

Theoretical consideration was extended to describe the influence of illumination on the free molecular flow of a pure vapor through a capillary or porous medium.

Light-induced transport of sodium molecules in nitrogen under the action of a cw Ar^+-laser was studied experimentally. This phenomenon shows as a rather slow "bleaching" of the Na_2 absorption bands excited by a laser pulse without saturation. The magnitude of the "bleaching" and its time dependence were determined as the functions of the laser intensity and beam diameter. This observation was ascribed to the decrease of the molecular number density in the illuminated area because of the molecular diffusion to the dark part of the sample.

TuQ3

The nonlinear response function for anisotropic polaritons in orthorhombic crystal.

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In the process of light scattering by polaritons in a nonlinear crystal with no center of symmetry, the infrared equilibrium fluctuations spectrum of electromagnetic field is converted into the visible range. As a rule, the model of transverse polarized polaritons is used for analysis of these spectra. However, if an IR wave in a biaxial crystal is not polarized parallel to one of crystallographic axis, it must be connected with two or three optical phonons with normally oriented dipole moments. In general case there may exist two polaritons for a given arbitrary direction. Their polarization can be transverse only in the case of a certain wavevector orientation. We will call such quasiparticles anisotropic polaritons. The nonlinear response function in this case depends from polariton wavevector direction and special model must be used for the calculation of spectra.

On the base of the formula introduced in [1], we supposed the gain factor for scattering by anisotropic polaritons as:

$$G = Im(4\pi \sum_{j,k=1}^{3} \chi_j \chi_k D^*_{jk} + \gamma) = 4\pi * G_2/(R^2 + I^2) + Im\gamma$$

where $\chi_k = \chi_{ijk}(\omega_s, \omega_l, -\omega_p) e^i_s e^j_l e^k_p$, are quadratic susceptibility components, γ is the cubic susceptibility, e_s, e_l, e_p are unit polarization vectors of signal, laser and polariton waves. We introduced the main value of dielectric function and the components of quadratic susceptibility as complex values: $\varepsilon_k = \varepsilon'_k + i\varepsilon''_k$, $\chi_k = \chi'_k + i\chi''_k$. In this case the formula for the quadratic susceptibility contribution is:

$$G_2 = (q_{jk}R + p_{jk}I)(\chi'_j\chi''_k + \chi''_j\chi'_k) + (q_{jk}I - p_{jk}R)(\chi'_j\chi'_k - \chi''_j\chi''_k) \qquad (1)$$

where $R = \eta_1\eta_2\eta_3 - 2\mu_1^2\mu_2^2\mu_3^2 - \eta_1(\varepsilon''_2\varepsilon''_3 + \mu_2^2\mu_3^2) - \eta_2(\varepsilon''_1\varepsilon''_3 + \mu_1^2\mu_3^2) - \eta_3(\varepsilon''_1\varepsilon''_2 + \mu_1^2\mu_2^2)$,
$I = \varepsilon''_1\varepsilon''_2\varepsilon''_3 + \varepsilon''_1(\mu_2^2\mu_3^2 - \eta_2\eta_3) + \varepsilon''_2(\mu_1^2\mu_3^2 - \eta_1\eta_3) + \varepsilon''_3(\mu_1^2\mu_2^2 - \eta_1\eta_2)$

The spectrum coordinats will be the wavenumber ω and wavevector value $|k|$, where $\mathbf{k} = \mathbf{k}_l - \mathbf{k}_s$. Variable $\mu = |k|/\omega_p$, components of μ along 1,2,3 axis are μ_j, and $\eta = \mu^2 - \mu_j^2 - \varepsilon'$. Coefficients in formula (1) are (m,n=1,2,3):
$q_{jk} = \mu^2(\mu^2 - \mu_n^2 - \mu_m^2) + \varepsilon'_n(\mu_m^2 - \mu^2) + \varepsilon'_m(\mu_n^2 - \mu^2) + \varepsilon'_n\varepsilon'_m - \varepsilon''_n\varepsilon''_m$, if $j = k \neq n \neq m$
$p_{jk} = \varepsilon''_n(\mu_m^2 - \mu^2) + \varepsilon''_m(\mu_n^2 - \mu^2) + \varepsilon'_n\varepsilon''_m + \varepsilon''_n\varepsilon'_m$, if $j = k \neq n \neq m$
$q_{jk} = q_{kj} = \mu_j\mu_k(\mu^2 - \varepsilon'_n)$, $p_{jk} = p_{kj} = -\mu_j\mu_k\varepsilon''_n$, if $j \neq k \neq n$

Obtained formulas have been used for the calculation of some areas of α -iodic acid orthorhombic crystal polariton spectra. Comparison with the observed spectra permit us to explain some peculiarities concerned with anisotropy of optical phonons and polaritons and cannot be explained within the scope of transverse polarized polaritons model.

1.V.L.Strizhevskii, Yu.N.Yashkir, Phys.Stat.sol.(b),61,1974,p.353.

TuQ4

INTERACTION OF OPTICAL COHERENT EXCITED IMPURITY SYSTEM WITH HEAT PULSE BALLISTIC PHONONS

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It is studied the effect of the ballistic phonons of heat pulses of the nanosecond duration on the inverted photon echoes in ruby with the concentration of Cr^{3+} ions of 0.2 wt.% and 0.03 wt.% and in LaF_3:Pr^{3+} for 4777 A ($^3P_0$ - $^3H_4$) transition with the concentration of Pr^{3+} ions of 1 wt.% at temperature 2 K. The heat pulse ballistic phonons are generated by fast (~10 ns) electrical excitation of thin (~10^{-6}-10^{-5}cm) Cu-film, by resistance 50Ω, deposited on to one polished face of a sample in parallel axes C_3. The photon echo was used as the phonon detector. It was observed experimentally the full recovering of the echo intensity in the ruby and significant on the ions Pr^{3+} in LaF_3 if the each impurity ion was interacted with two alike phonon pulses after the recording and, accordingly, reading lazer pulses. The basic property of the photon echo, which allows to use of one as a detector of processes without coherent losses, lies in an independence of the echo intensity from unhomogeneity width. This has allowed to conclude that the main effect of the ballistic phonon pulses consists in shifts of the energy levels, instead of in relaxation transitions. It is unexpected result, which do not be interpreted within the framework of usual representation about the mechanism of action heat phonons on impurity ions. To study the interaction mechanisms the some attention was given to measurements, conducted under different duration of the phonon pulses and different delay times between them, to investigation of additivity and commutativity of the phonon pulses action and to comparison of the theoretical and experimental results.

TuQ5

OPTOACOUSTIC AND MASS SPECTROSCOPY DETECTION OF SPINODAL DECAY AT LASER EVAPORATION OF GRAPHITE.

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Department of Chemistry, Moscow State University
Department of Chemistry, Moscow State University, 119899, Moscow, Russia

Steady-state laser evaporation of the polycrystalline graphite sample with linear dependence of crater depth, thermoacoustic pressure and recoil pressure of evaporated substance on laser power density at the range of 0.01-0.3 GW/cm2 has been observed by common optoacoustic procedure. Estimated values of recoil pressure was equal to about one half of equilibrium saturated vapour pressure along subcritical region of evaporation curve what was in accordance with the metastable state of liquid carbon.

Threshold transition of evaporation regime to hydrodynamic expansion has been detected by proposed optoacoustic procedure as equality of thermoacoustic and recoil pressure pulse amplitudes under laser irradiation with power density more than 0.3 GW/cm2. Large cluster ions up to million atoms have been appeared in time-of-flight mass spectra at the same range of power density. The phenomenon has been explained by spinodal decay of metastable liquid carbon which began at intersection of spinodal curve by liquid-vapour curve below carbon critical point.

Critical state of carbon has been produced when equilibrium laser evaporation of the low-density foam graphite at power density range of 0.006-2.5 GW/cm2 occurred in regular air gaps of its "sandwich-like" structure. Formation of carbon critical state has been confirmed by appearance of giant carbon cluster ions observed in time-of-flight mass spectra and time-resolved optoacoustic detection of compression acoustic pulse of bulk evaporation besides the same one of surface evaporation. The efficiency of acoustic wave generation in the case of foam graphite bulk evaporation has been 2.7 times more than in the case of foam and polycrystalline graphite surface evaporation. This value correlates well with the ratio value of critical pressure and vapour pressure at the spinodal intersection point which has been calculated for Van-der-Vaals gas.

TuQ6

INDUCED ABSORPTION AND STIMULATED FORWARD SCATTERING OF *XeCl*-LASER RADIATION IN TETRACHLOROMETHANE

E.L.Bubis, Yu.N.Konoplev, L.V.Soustov

Tetrachloromethane (CCl_4), which is highly transparent in a wide wavelength range, is traditionally employed in spectroscopy and nonlinear optics. CCl_4 is transparent at the wavelength of a *XeCl* laser (when λ = 308 nm, linear absorption $\alpha_0 \cong 5 \times 0^{-3}$ cm^{-1}), however, it has significant two-photon absorption ($\beta = 1.9 \times 10^{-3}$ cm/MW) [1]. The report presents the results of our study of the influence of pulse *XeCl* laser radiation on the optical transparency of CCl_4 in liquid phase under various radiation doses. In the experiment, we used non-polarized multimode multifrequency radiation from a laser of the Lambda Physik company with pulse duration 30 ns at F = 1 Hz. To increase the power density in the medium under study up to $I \leq 60$ MW/cm^2, the beam was compressed and collimated by a telescope with four-fold magnification. The beam diameter was 1.5 mm, the divergence was 10^{-2} rad. The volume of liquid in the 5 cm cell was 10 cm^3.

It was found that when $I \geq 10$ MW/cm^2, the CCl_4 optical transparency decreases with an increase in radiation. The process is caused by two-photon dissociation of CCl_4 and by accompanying generation of molecular chlorine which we have recorded by characteristic diffusive absorption band whose maximum is around λ = 330 nm [2.3]. When $I \cong 60$ MW/cm^2 and radiation $\cong 20$ J/cm^3, $\alpha_0 = 0.4$ cm^{-1} at λ = 308 nm. and at λ = 330 nm the cell transmission $T < 1\%$. Such process of deterioration was nonlinear when the radiation dose is the same, but at $I \leq 2$ MW/cm^2 no significant increase of absorption was observed. It should be noted that the process of two-photon dissociation may be used for destruction and transformation of a wide class ozone-destructive substances, such as freon in particular, to which CCl_4 also belongs.

In the experiment, the stimulated forward scattering with divergence $\geq 10^{-1}$ rad was observed starting with $I > 2$ MW/cm^2. By using the dark-field method, we stated that the energy of scattered radiation almost linearly increases when I grows. At $I \cong 60$ MW/cm^2 the scattered radiation reaches 20% of the incident energy. To our opinion, the observed scattering may be attributed to stimulated temperature scattering (STS) caused by two-photon absorption.

References

1. E.L.Bubis, L.V.Soystov, Journal of Applied Spectroscopy, 1993, v.58, 3-4, pp. 347-350
2. V.V.Bertzev et al., Optics and Spectroscopy, 1991, v. 70, issue 1, pp. 97-100
3. C.Okabe, Photochemistry of small molecules, M.:Mir, 1981, p.500

TuQ7

Investigation of the multiphoton ionization of Ba atoms with photoelectron spectroscopy.

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In the last decade, investigation of the angular distribution of photoelectrons has been used for studying the ionization of atoms. The possibility of per forming a complete quantum-mechanical experiment on photoionization is special interest in these investigations. To carry out such an experiment, we should measure the angular distribution and spin orientation of photoelectrons. Presently, measuring the spin of photoelectrons is a complex experimental problem, which is associated with considerable experimental error due to inaccuracy in measuring the orientation of the photoelectron spin with a detector of orientation.

The authors of [1] proposed the method of performing, a complete quantum-mechanical experiment on photoionization that includes measuring the angular distributions of electrons for optically oriented atoms. Such experiments can be carried out in two-stage excitation with polarized radiation.

This work presents the our experimental [2] and theoretical results of our investigation of the angular distribution of electrons. Three-photon ionization of Ba atoms occurs in accordance with the following scheme:

$$Ba[6s^2(^1S_0)] \rightarrow 6p^2(^1S_0) \rightarrow Ba^+[6s(^2S_{1/2}), 5d(^2D_{3/2,5/2})] + e^{(-)}$$

Use of linearly polarized radiation in the first stage made it possible to prepare an ensemble of oriented atoms in the $6p^2(^1S_0)$ state. For electrons that correspond to the 6s state of the ion, we studied the angular distriation of photoelectrons.

This work was supported by Optics, Laser Physics Program.

1. Klar, H., Kleinpoppen, H., J. Phys.B, 15, 933 (1982).
2. Elizarov A., Pis'ma Zh. Eksp. Teor. Fiz. 62, 23 (1995)

TuQ8

RESONANT STRUCTURE OF DOUBLY-CHARGED IONS YIELD AT NONLINEAR IONIZATION OF Sr AND Ba ATOMS IN INFRARED SPECTRAL RANGE

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Our previous studies showed that the mechanism of doubly-charged ions A^{2+} formation at nonlinear ionization of alkaly-earth atoms in IR spectal range in contrary of their ionization in visible spectral range is not step-wise. In the case of ionization in IR spectral range the target for doubly-charged ions formation A^{2+} are neutral atoms. However the resonant structure in dependencies of the yield of A^{2+} ions on frequency ω of laser radiation in IR spectal range is not unambigiously identified yet.

To elucidate this task we performed a number of experimental investigations of a functions $N^{2+}(\omega)$ at ionization of Sr and Ba atoms in the field of laser on colour centres (ω= 9300-9000 cm^{-1}) at different field strengths ($\mathcal{E}$=10^8-5 10^8 V/cm).

We observed that the widths of resonant maxima in dependencies $N^{2+}(\omega)$ are sufficiently larger than at ionization of Sr and Ba atoms in visible spectral range. It was also discovered that widths and amplitudes of these maxima are strongly dependent on $\mathcal{E}$.

The analisis showed that the observed resonant structue of these dependences $N^{2+}(\omega)$ is caused by multiphoton excitation of perturbed in result of AC-Stark effect states of neutral atoms. Note that the perturbation of Sr and Ba atoms in this case is significant. In separate cases shift of these states was $\Delta\mathcal{E} \simeq 10^3$cm^{-1}.

TuQ9

THE SEARCH AND STUDY OF LONG-LIVED STATES IN A GAS BY COHERENT TRANSIENT SPECTROSCOPY

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Coherent radiation action on the rarefied gas is able to create the polarization moments of levels. From the macroscopic viewpoint, this is equivalent to induction of either macroscopic magneticity of gaseous sample (orientation), or quadrupole electric moment (alignment) or some higher moments. Specific external conditions are necessary to destroy these polarization moments, which, in its turn, explains their long life. Investigation of decay dynamics of such states provides important data on matter. Such investigation is especially interesting in a gas media, which admits the variation of type and strengths of interaction between particles in a wide range. Besides, just in a gas the very effective technique, based on coherent transients, is applicable for investigation of polarization moments decay [1].

By using method of stimulated photon echo of specially chosen polarizations of exciting pulses, the generation and collisional decay of lower polarization moments (population, orientation and alignment) were investigated in molecular gas SF_6 and its mixtures with buffers Xe and He under excitation of CW frequency tunable CO_2 laser [2]. As a result of comparison of decay rates of polarization moments at different rotational-vibrational transitions od SF_6, the conclusion is made about possible J-dependence of these rates. On the base of comparison of population and higher polarization moments decay rates, the prevailed contribution of non-elastic collisions is revealed. Elastic part of decay rate, representing just depolarizing collisions, is characterized by small cross section (significantly lower than the gas kinetic one), is controlled by gas pressure. The mechanisms of relaxation and application perspectives of such states are under consideration.

References

1. I.V. Yevseyev, V.M. Yermachenko, V.A. Reshetov, ZhETF, 1980, v. 78, p. 2213.

2. L.S. Vasilenko, N.N. Rubtsova, E.B. Khvorostov, ZhETF, 1998, v. 113, p. 1.

TuQ10

Two-Photon Induced Thermal Nonlinearity in Ge.

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The phase conjugation in the wavelength λ range 3 - 5 μm is rather rarely used in a practice yet. The reason is the absence of the nonlinear material providing high enough four wave mixing efficiency R and short enough decay time τ simultaneously. The preliminary calculations showed that nonlinear response (NR) via two-photon free carrier generation (TFCG) could help to solve this problem, and Ge is the suitable material for this.

The efficiency $R \sim 1$ was achieved experimentally[1] at $\lambda = 2.94$ μm in Ge. It was assumed that the classic thermal (CT) NR should be low due to the small linear absorption coefficient $\alpha_0 \le 0.1$ cm^{-1}, so TFCG NR would prevail. The analysis of dynamics of R had shown, however, that the reflection is determined by the thermal NR, not by the electronic one. The observed thermal NR is not usual. It is initiated by TFCG and it may be titled as two-photon induced thermal (TPIT) NR. The principal difference between TPIT and CT NR is the dependence of the effective absorption coefficient α on I^2, where I^2 is the squared sum of the interacting waves intensity. Due to induced absorption is $\sim I^2$, the nonlinear susceptibility for TPIT appears to be 7-th order parameter $\chi^{(7)}$ unlike $\chi^{(3)}$ for CT and $\chi^{(5)}$ for TFCG. Similar to CT, τ for the TPIT is $\sim 0^{-2}$ (large-period grating, θ is the angle between probe and fair pump waves). High thermal conductivity of semiconductors provides a possibility of obtaining τ of order of ~ 0.1 μs.

The values of $\chi^{(3)}_{eff}$, τ and $\chi^{(3)}_{eff}/\tau$, which characterize the NR efficiency[2], are

NR type	TPIT	TFCG	CT (chloroform)
$\chi^{(3)}_{eff}$, esu (I = 1 MW/cm^2)	$1.4 \cdot 10^{-6}$	$7 \cdot 10^{-9}$	$4 \cdot 10^{-8}$
τ, μs (θ = 0.1 rad)	0.5	$3 \cdot 10^{-3}$	0.3 (small-period grating)
$\chi^{(3)}_{eff}/\tau$, esu/s	2.8	2	0.1

1. A.E.Vidavskii, V.I.Kovalev and V.M.Raukhman. SPIE Proc., v.2771, p.104 (1996).

2. V.I.Kovalev. Bull. of Russian Academy of Sci., Ser. Phys., v.60, No.6, p.908 (1996).

TuQ11

LIGHT-INDUCED ABSORPTION IN PHOTOREFRACTIVE $Bi_{12}TiO_{20}$

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$Bi_{12}TiO_{20}$ crystal is of great interest to the investigation and application of nonlinear phenomena such as two-beam coupling, optical phase conjugation and bistability, photorefractive spatial solitons and surface waves. We report on the study of the photorefractive properties and light-induced absorption in nominally pure $Bi_{12}TiO_{20}$ crystals grown by the high-temperature-solution-growth technique. The build-up time of light-induced absorption at λ=633 nm (see Fig. 1(a)) decreases with light intensity and runs into ~100 s for I_0=50 mW/cm^2. The steady-state magnitude of a change in light absorption exceeds 0.5 cm^{-1} for I_0>10 mW/cm^2. We observed the drop in absorption ~0.35 cm^{-1} in the dark condition after two days (Fig. 1(b)). However, the further decay of light-induced change in absorption was continued over the next week. We experimentally found the dependence of the photorefractive two-beam coupling at λ=633 nm on light intensity in the range from 0.5 to 30 mW/cm^2. The model of the crystal with deep and shallow traps has been employed to the explanation of the experimental results. The relevant theoretical dependencies are plotted in Fig. 1. We have estimated the material parameters of $Bi_{12}TiO_{20}$ crystal from the fit this two-level theory to the experimental data.

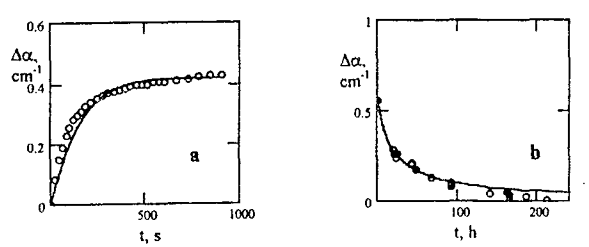

Figure 1. Build-up (a) and dark decay (b) of light-induced absorption

TuQ12

Photoinduced Transport of Particles on Solid Surfaces

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In recent years, much effort is expended in studying of surface phenomena caused by optical radiation [1-3]. Interest in its impact hinges on a widespread application which the results of such studies find in advanced know-how. However, despite a many theoretical and experimental reports on the matter, the kinetics of surface phenomena on illuminated areas is still incompletely understood. The effect of a light field on surface atoms is commonly accounted for in terms of radiationless relaxation of electronic interaction between atoms and surface, which may end in desorption of the atoms. On the other hand, incident light polarized particles. The induced interaction of polarized particles with one another and with the external electromagnetic field may sometimes be fairly strong. In contrast to the cited papers which mostly deal with the behavior of an individual adsorbed particle in an external field, our goal is to analyze photoinduced dipole-dipole lateral interaction of such particles.

In this work the one-dimensional problem on physical adsorption of atoms on a dielectric, semiconductor, or metal surfaces is formulated in the form of a kinetic equation governing establishment of local adsorption equilibrium in the case of a nonuniform space distribution of the optical radiation intensity incident on the surface [4].

Influence of the optical field effect to collective behavior of atoms of high density on the solid surface is investigated. It is assumed that initial distribution of atoms ensemble is uniform, but distribution of optical radiation intensity cross section has two-dimensional Gaussian form. It is demonstrated that lateral interaction of induced dipoles entails surface migration of adatoms beyond the illuminated area to form on it either a "crater" or, conversely, a "hillock".

The obtained results shows the possibility of nonuniform structures formation in two-dimensional lattice gas by the use of coherent light field.

1. N.V. Karlov, A.M. Prokhorov. // Sov. Phys. Uspekhi., 1977, V.123, N.1, P.57.
2. V.A. Kravchenko, A.N. Orlov, J.N. Petrov, A.M. Prokhorov,
//Proceedings of the IOPhAN, M., 1988, V.11.
3. I.N. Abramova, E.B. Alexandrov, A.M. Bonch-Bruevich, V.V. Khromov
// JETPh Lett, 1984, V.39, N.4, P.172.
4. V.V. Andreev, G.N. Ostriakov and G.G. Telegin, Chem. Phis. Reports//1997, V.16, N.1, P.138.

TuQ13

LIGHT-INDUCED ABSORPTION IN CERIUM DOPED LEAD BARIUM NIOBATE

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Lead barium niobate, $Pb_{1-x}Ba_xNb_2O_5$ (PBN)[1], is an attractive candidate for electro-optic and photorefractive applications such as holographic data storage. Intensity dependent absorption in photorefractive materials has a significant effect on optical data storage. We investigate light-induced absorption through pump-probe measurements in $Ce{:}Pb_{0.5}Ba_{0.5}Nb_2O_5$ grown by vertical Bridgman method. We used an argon-ion laser (488 nm) as a pump and measured the light-induced absorption coefficient, its build-up and decay times by monitoring the transmitted power of a weak probe beam from a HeNe laser. The light-induced absorption coefficients show the strong dependence on the pump intensity as shown in Fig.1. The probe beam with extraordinary polarization shows the more induced absorption than with ordinary polarization. This strong asymmetry with respect to the polarization may be explained by the vacancies that act as the shallow traps. The induced absorption was measured as a function of temperature in the range of 20-120℃. Thermal effects are not responsible for the induced absorption. The buildup and decay rates are nonlinear with respect to the pump intensity with a saturation at high pump intensities. We estimate the effective dark decay rate of the population of the traps as 0.5 s^{-1} and the density of the shallow traps as about 5×10^{16} cm^{-3}.

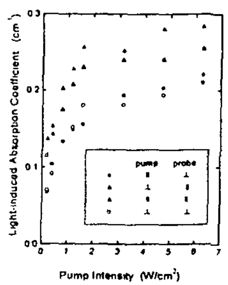

Fig.1.Light-induced absorption coefficient at 633 nm as a function of the pump intensity at 488 nm in Ce:PBN.

1. A.Y. Liu, M.C. Bashaw, L. Hesselink, M. Lee, R.S. Feigelson, Opt. Lett. 22, 187 (1997).

TuQ14

NONLINER FREE-CARRIER ABSORPTION IN NONPARABOLIC III-V SEMICONDUCTORS

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The absorption spectrum of a semiconductor can be subdivided into several domains according to the wavelength. For photon energies smaller than the fundamental band gap free-carrier absorption takes a predominant role. This paper deals with the optical nonlinearities connected with the free carrier absorption in n-doped bulk III-V semiconductors. When the incident electromagnetic wave energy increases the temperature of the free-electron system deviates from the lattice temperature, leading to nonlinear effects. Hereto, we developed a model fully taking into account the nonparabolic structure of the conduction band: in the dispersion relation, the density of states and electron wave functions. In our three-particle intraband model the free-carrier absorption process is assisted by impurity, thermal and hot optical phonon and acoustic phonon scattering. At moderate and high doping concentrations the ionized impurities take the leading role. Collective effects such, as screening by free electrons is included as well. Computations are performed for GaAs, InAs and InSb in order to highlight the striking influence of the increase of the nonparabolicity effect when the band gap decreases. The wavelength, the electron density, the electron and lattice temperature dependencies are discussed. In almost all cases the present calculations give values smaller (up to 100%) than those obtained by other, more relaxed nonparabolic models. We demonstrate that the nonparabolicity is important at all electron concentrations. When the electron temperature increases the absorption coefficient can increase or decrease depending on the doping concentration. The competition between phonon and impurity assisted absorption explains these phenomena. Our results confirm experimental data [1,2].

[1] A.S.Jordan, J.Appl.Phys. 51, 2218 (1980),
[2] T.Elsaesser, R.J.Bauerle, and W.Kaiser, Phys.Rev. B 40(5), 2976 (1989-I).

TuQ15

NARROW LOW-FREQUENCY RESONANCES OF DIELECTRIC PERMITTIVITY IN L-ASPARAGINE MONOHIDRATED NONLINEAR OPTICAL CRYSTALS

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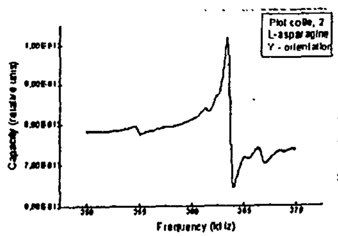
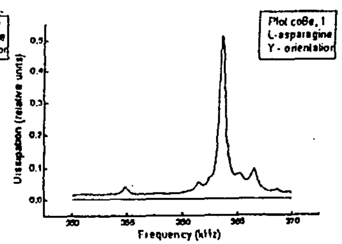
We performed the mesurements of the complex dielectric permittivity of l-asparagine monohidrated organic crystals in range from 100 Hz up to 40 Mhz. The bright narrow resonances in both of the real and imaginary parts of dielectric constant were observed in region from 200 KHz up to 10 MHz (Figs 1, 2). The strong dependence not only the parameters of resonances but its existenceas well on the cut and orientation of the samples was found. Earlier similar strongly non-Debye relaxation at low frequencies was observed at pure and doped by metallic ions LiNbO3 crystals at KHz [2] regions. The nature of the resonances are discussed.

[1] P. C. Barbosa, J. A. C. de Paiva, J. Mendes Filho, A. C. Hernandes, J. P. Andreeta, A. S. B. Sombra, Phys. Stat. Sol. (a), 125,723 (1991); E. F. Almeida, A. V. Ghiner, A. C. Hernandes, J. A. C. de Paiva, A. S. B. Sombra, G. I. Surdutovich, OSA Anual Meeting, Rochester, USA, October, 1996, Abstracts.





TuQ16

Emission of particles by solid-phase laser-induced destruction of silicon surface

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It is common knowledge that the process of laser destruction of material can also take place in the solid phase, i.e. when the acting radiation power density is below the threshold value I_{tresh}, whereby melting of the material starts ($I_{tresh} < I_{melt}$, where Imelt is the material melting threshold), but is enough for generation of substantial concentration of defects in the surface layer, such as vacancies and dislocations which can accumulate into larger defects in the field of thermoelastic stresses and thus initiate microcracking.

A microcrack generation (opening) is in a number of cases accompanied by any emission phenomena being unrelated to thermal or photoemission. According to papers / /, emission of electrons, ions, charged or neutral particles (clusters), for example, may be due to the excess of the material yield strength σ or ultimate strength σ_f owing to thermoelastic stresses σ^* in the material surface layer. Thus, registration of the particles escaping from the material surface on its irradiation by the pulses having power density lower than I_{tresh} would point to occuring of the processes of the surface local solid-phase microdestruction. It should be expected that the escaping particles will show elevated temperature and, hence, marked thermal glow.

This paper presents the results of investigation into the process of silicon surface solid-phase destruction under YAG.Nd laser pulses. Registration of the surface microdestructions was performed with regard to thermal glow of the particles escaping from the surface. It has been found out that under the effect of laser pulses with $I^*<I<I_{melt}$ (I^* is the minimum laser pulse power density whereby the emission of particles was still observed) the emission of particles takes place which, in our opinion, is related to microdestructions of the silicon surface.

TuQ17

Polarizabilities and Hyperpolarizabilities H-like Rydberg Levels

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The linear and quadratic on the intensity of light field perturbation of hydrogenlike levels with an arbitrary principal quantum number n is analysed in detail based on the frequency, ω, and n-dependences of polarizabilities, $\alpha_{nl}(\omega)$, and hyperpolarizabilities, $\beta_{nl}(\omega)$. The account of terms with β_{nl} permits to estimate the dependent on ω critical intensities limited the use of standard quadratic Stark effect approach for the analysis of perturbation of excited atomic levels in a laser field. The cases of below-threshold and above-threshold frequences are considered. The mixing of $|nl>$-levels with different orbital momenta l by a light field is also discussed.

For an analysis of $\alpha_{nl}(\omega)$ and $\beta_{nl}(\omega)$ we use a new representation of Coulomb Green function [1] which simplifies principally an analytical calculations in a comparision with the existing methods. $\beta_{nl}(\omega)$ was calculated as a one-dimensional series of hypergeometric functions ${}_2F_1$ and $\alpha_{nl}(\omega)$ for an arbitrary n is presented in terms of the independent of n function ${}_2F_1$ and two real finite polynomials $\phi_{nl}(1/\tilde{\omega})$ and $\varphi_{nl}(1/\tilde{\omega}^2)$, where $\tilde{\omega} = 2n^2\omega/Z^2$ (in atomic units). For above-threshold frequences ($\tilde{\omega} > 1$) the square of $\phi_{nl}(1/\tilde{\omega})$ is proportional to the photoionization cross section on $|nl>$-state. The scalar (α^0_{nl}), symmetric (α^s_{nl}) and antisymmetric (α^a_{nl}) parts of $\alpha_{nl}(\omega)$ have a similar structure. For an example,

$$\alpha^0_{nl}(\omega) = -\frac{1}{\omega^2}\Bigg\{1 + \varphi_{nl}\left(\frac{1}{\tilde{\omega}^2}\right)$$

$$+\frac{1}{3(2l+1)}\left[(l+1)\phi_{nl+1}\left(\frac{1}{\tilde{\omega}}\right)^2 T_{l+1}(\omega) + l\phi_{nl-1}\left(\frac{1}{\tilde{\omega}}\right)^2 T_{l-1}(\omega) + \{\omega \to -\omega\}\right]\Bigg\}.$$

Here the same for all n "hypergeometric" part is

$$T_{\gamma=l\pm1}(\tilde{\omega}) = \frac{\nu}{1+\gamma-Z\nu}\,{}_2F_1(1, 2\gamma+2, 2+\gamma-Z\nu; x),$$

where $x = -(n-\nu)^2/4n\nu$, $\nu = n/\sqrt{1 \mp \tilde{\omega} - i0}$. The simplest analytical approximations for the polarizabilities are derived for a number of limiting cases.

[1]. Krylovetsky A.A., Manakov N. L. and Marmo S. I., submitted in JETP.

TuQ18

Exact Steady-State Density Matrix for Atoms in A Monochromatic Elliptically Polarized Field

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Many problems of the resonant interaction of atoms and polarized light require knowing the steady-state solution of the generalized optical Bloch equations for the atomic density matrix, with allowance for the Zeeman structure of the energy levels involved.

Earlier (see refs.[1]) the exact steady-state solution of the optical Bloch equations has been found in the general case for two groups of transitions $F_g = F \to F_e = F-1$ and $F_g = F \to F_e = F$ where F_g and F_e are the total angular momenta of the ground (g) and excited (e) states. Transitions $F_g = F \to F_e = F+1$ were studied in [2], where an exact solution was obtained for the specific cases of linearly and circularly polarized fields. For arbitrary light ellipticity the steady-state density matrix in analytical form was found only for transitions involving small values of the angular momentum in works on laser cooling. At the same time, experiments are ordinary done using transitions with large values of the angular momenta, for example, $F = 3$ for ^{85}Rb and $F = 4$ for ^{133}Cs.

In this paper we present the compact analytical expression for the steady-state density matrix of atoms having momenta $F_g = F \to F_e = F+1$ in a monochromatic elliptically polarized light. We write the atomic density matrix in terms of dot products of spherical tensor operators and irreducible tensors constructed by a field polarization vector. The tensor structure and symmetry of the solution are clarified. The solution properties are discussed and some applications are outlined.

1. Smirnov V.S., Tumaikin A.M. and Yudin V.I., *Sov. Phys. JETP*, **69** (1989) 913; Taichenachev A.V., Tumaikin A.M., Yudin V.I., Nienhuis G., *JETP*, **81** (1995) 224.

2. Macek J., Hertel I.V., *J.Phys. B*, **7** (1974) 2173; Nienhuis G., *Phys. Rev. A*, **26** (1982) 3137.

TuQ19

IR STIMULATED EMISSION UNDER THE EXCITATION OF RYDBERG STATES IN CS VAPOURS.

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The scope of the work is to investigate the new ways of free atoms laser excitation to higher levels. It is very interesting for experimental research of the rydberg matter.

The problem of so-called rydberg matter is an actual one in the current moment. This matter is the result of collective interactions of valent electrons in high-excitated atoms. Rydberg matter has a set of remarkable features. It posesses the properties of metal but this matter is transparent in the optic region of the spectrum and has a very low density. The excitation of the caesium vapours under conditions of the isolated resonance was realized in our experiments, under the resonance of the frequency of pumping laser with the one of the atomic transition between two upper levels of Cs atom.

The given way is a more simple one from the technical point of view because it does not require a coincidence of several laser pulses in the space at the same moment of time. The excitation was registrated by the observation of the powerful stimulated IR emission from the upper levels of Cs. The following common features of arising of this excitation were found:

- the number of IR lines observed depends upon the resonance frequency ϖ_L to which the exciting laser is tuned;
- IR lines generation is cascade; the stimulated IR emission from upper levels leds to the population of lower-layed energy states, from those, in turn, stimulated IR transitions to the lowest layers happen;
- the initial state for this cascade process is always the upper level of transition to that the frequency ϖ_L of the exciting laser is tuned.

The results obtained fully confirm the possibility of effective excitation of high (rydberg) states of alcaly metal atoms when the frequency of pump laser is tuned near the isolated resonance with the transition between the two upper levels. These results also may be applied in the development of compact and effective convertors of visible laser emission to far IR region.

TuQ20

Kinetics of Metastable States of Antiprotonic Helium Controlled by Sequences of Short Laser Pulses

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The recently discovered metastable states of $\bar{p}He^+$ [1] are of significant interest as a means of accumulating antimatter in neutral atoms. However, the time spectrum of delayed annihilation is a global and non-selective characteristic of the system as a whole, not of individual metastable states. By means of short resonance laser pulses one can change the initial conditions for further decay process, thus making it informative about the individual energy levels [2]. The action of resonance laser pulses on the decay rate of the metastable states of the antiprotonic helium atomcules is studied numerically. A new multi-pulse method for the control of state populations and decay kinetics is developed. As it is known the transitions in metastable antiprotonic helium occur between the states $(n,l) \to (n-1,l-1)$ that form isolated cascades, each finished by an annihilation state.

Because of large $l \sim 38$ and large number of Zeeman sublevels the π-pulse does not exist for the whole transition. We show that a linearly polarized pulse can provide the population inversion from 1 to 0.85 depending on the coherence of the upper level and the area of the pulse. It is shown that the time sequence of the inverting pulses determines the direction of the transitions within the cascade. Choosing the proper sequence one can either push the atomcules down the cascade to the annihilation states, or, on the contrary, halter the decay by populating higher energy long-lived states. By properly chosen IR pulses intercascade transitions can be induced. Hence it becomes possible to study the populations of the high-l states that cannot be observed directly by traditional methods.

The kinetics of metastable states of $\bar{p}He^+$ subjected to an utrashort (femtosecond) laser pulse is studied. Due to the considerable spectral width, such a pulse can provide parallel transitions in two or three cascades simultaneously, depending on its duration and carrier frequency. Moreover, it can simultaneously push down the atomcules from all metastable states to an annihilation state.

A method is proposed for experimental study of mechanism and kinetics of anomalously fast decay of higher energy states with $n > 40$, based on the induced population of these states followed by the analysis of changes in the delayed annihilation time spectrum.

[1] M.Iwasaki et al. Phys. Rev. Lett. 67, 1246 (1991).
[2] V.L.Derbov, L.A.Melnikov, I.M.Umanskii, and S.I.Vinitsky. Phys Rev. A, 55, 3394 (1997)

TuQ21

HYPER-RAMAN SCATTERING OF LIGHT: FORBIDDEN SCATTERING MECHANISMS

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The hyper-Raman scattering (HRS) of light is an nonlinear process at which two photons of incident radiation are absorbed simultaneously, and a scattered light photon and a phonon are created. Thus, in hyper-Raman process a change in the vibrational state of lattice is produced, but the electronic states remain unchanged. We assumed that the virtual intermediate states are the Wanier excitons. The intraband Fröhlich exciton-lattice interaction gives the dominant contribution to the HRS intensity. The following chain of intermediate states, *s-p-s*, corresponds to this scattering process. However, forbidden scattering mechanisms can result in different features of the HRS intensity frequency dependence under resonant conditions. If the selection rules allow two-photon transition to the s-exciton state, the dipole Fröhlich interaction results in the transition to the p-exciton state (*p-s-p*), whereas the qudrupole interaction induces the transition to the s-exciton state (*p-s-s*). Taking into account the forbidden scattering mechanisms (*p-s-p* and *p-s-s*), we have calculated the scattering cross-section σ at various excitation wavelength for the CdS crystal (Fig.1.). The dashed and dotted lines correspond to scattering cross-sections for different values (0.1 and 0.2) of the parameter M_{cv} [1]. The solid line describes the dependence on the incident radiation wavelength for the allowed HRS (*s-p-s*).

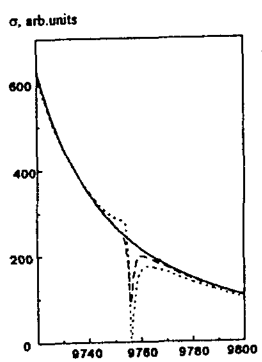

Fig.1.

1. K.C.Rustagi, F.Pradere, and A.Mysyrowicz, Phys.Rev.B, 8, 2721 (1973)

TuQ22

Magnetic Field of Laser Plasma Formed at Radiation of a Target by a HF-laser

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This report describes a study of toroidal component of magnetic fields associated with a laser plasma formed at radiation on a target (spot of irradiation $\approx 1 cm^2$) by chemical HF-laser (λ=2,7-3,5 μm). The target (from carbonaceous plastic material) was located in a vacuum chamber (air pressure was about $3\cdot10^{-4}$ Pa). The output of the laser system (where the impulse chemical HF-laser was used [1]) ranged from about 100 J to about 2000 J in a 1-4 μs pulse, or about 60-2000 MW. The magnetic fields were detected by means of a inductive magnetic probe (as described in [2,3]).

The detail analysis of this phenomena is investigated numerically for wide range of radiation and hydrodynamic parameters. The mathematical model includes a system of hydrodynamics equations, equation for a magnetic field in a plasma in linear approximation (describe the convection, diffusion and generation of the magnetic fields) and wave equation for consideration of the magnetic fields outside of the laser plasma flame. The numerical results of calculations are obtained as for dielectric target, as for target which conduct current . For both types of targets and in the space from both side from a target the directional diagram for magnetic fields are considered. The current-density distributions which produced the magnetic field as in a plasma as in the conductive target are presented. The experimental results for a magnetic fields are compared with numerical calculations.

1. Bashkin A.S., Igoshin V.I., Oraevskiy A.N., Sheglov V.A. Chemical lasers. Moscow, Nauka, 1982.
2. Zakharov N.S., Shainoga I.S. Izvestiya Akademii Nauk SSSR. Mekh. Zhidk. Gaza, 21, № 6, p. 135, 1986.
3. McKee L.L., Bird R.S., and Schwirzke F. Phys. Rev. A, 1974, v.9, № 3, p. 1305.

TuQ23

FILAMENTATION AND SBS IN TURBULENT PLASMA

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In the experiments on laser radiation interaction with plasma the conditions when ion-acoustic instability leads to turbulent state may be realized [1]. The thermal electron mean free path l_t in plasma with ion-acoustic turbulence is essentially less than mean free path l in laminar plasma and is determined by electron scattering on charge density fluctuations. If the scale $\lambda=1/|\mathbf{k}|$ of low frequency electron density perturbations is small $\lambda<<l_t$, then at the description of parametric instabilities the nonlocality of electron transport is essential [2]. In these conditions the theory of filamentation and stimulated Brillouin scattering (SBS) is given. The spatial coefficient of filament amplification in a turbulent plasma G_t, the scale of most effectively increasing perturbations λ_t and the threshold of radiation intensity I_t are found. The difference of these quantities from realizing in laminar plasma is given by the ratio $l_t/l << 1$: $G_t/G_l=(l/l_t)^{2/9}$, $\lambda_t/\lambda_l=(l_t/l)^{1/9}$, $I_t/I_l=(l_t/l)^{2/7}$. Because of turbulent noise anisotropy the quantities $G_t(\theta)$, $\lambda_t(\theta)$ and $I_t(\theta)$ depend on the angle θ between vector **k** and force **R** generating turbulence. In the case, when turbulent noise concentrates along **R**, the anisotropy degree of above mentioned quantities is given by the formulae: $G_t(\theta=0)/G_t(\theta=\pi/2)=0.61$, $\lambda_t(\theta=0)/\lambda_t(\theta=\pi/2)=1.3$, $I_t(\theta=0)/I_t(\theta=\pi/2)=1.9$. When electron density perturbation is stipulated by ion-acoustic wave potential vibrations, the turbulence leads to SBS threshold increasing $I_t/I_l=(l/l_t)^{5/7}>>1$. In the same conditions the SBS threshold anisotropy is given by the ratio $I_t(\theta_k=0)/I_t(\theta_k=\pi/2)=0.21$, where θ_k is the angle between scattering vector **k** and **R**. If electron density perturbation arises due to inverse bremsstrahlung absorption of radiation then SBS threshold and the degree of anisotropy are $I_t/I_l=(l_t/l)^{2/7}$; $I_t(\theta_k=0)/I_t(\theta_k=\pi/2) = 1.9$.

[1] Young P.E., Phys. Plasmas **2**, 2815 (1995).
[2] Silin V.P., Uryupin S.A., JETP **83**, 1118 (1996).

TuQ24

Mechanoluminescence of metal surface initiated by YAG:Nd laser pulses

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It is common knowledge that the action of rather high laser radiation on crystalline materials can be responsible for generation of various structural defects (vacancies, interstitial sites, dislocations, pores, cracks, etc.). In a number of cases these defects are capable of emitting radiation quanta in the process of their generation or movement. The intensity of this radiation (mechanoluminescence - ML) is largely dependent on the density and velocity of defects movement, which are, in their turn, governed by the velocity of thermoelastic stresses growth in the sample as the result of laser action. The temporal dependence and spectral composition of ML intensity have a very complex shape and, as far as we know, there does not exist, particularly for metals, any commonly accepted model that would permit to describe the mechanism of photon emission in the process of generation and movement of defects.

This paper presents the results of investigation of the laser-induced emissive rising of defects onto the surface and the destruction of the surface of W, Mo, Ti and Cu samples. The sample under study was placed into the vacuum hamber and subjected to the action of YAG:Nd laser pulses. The signal was removed from the back, with respect to the acting laser pulses, side of the sample. Consideration was being given to the spectral composition and glow kinetics of ML signal individual spectral lines by generation of thermoelastic stresses in the sample under the laser pulse. To reveal the contributions of oxidation processes to the ML signal, the investigations were pursued in vacuum and in the open air. It has been found out that the ML signal presents a set of individual spikes. The number of spikes in the signal grows, as the laser pulse energy increases. The study of ML signal evolution was conducted under irradiation of the sample by a sequence of pulses.

TuQ25

SELF FOCUSING OF LIGHT IN VACUUM

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Phenomenon of self focusing of EM waves in vacuum, being a strict analogy of well investigated light self focusing in nonlinear material media, arises due to influence of the own mass of photon beam on speed of light, prescribed by the theory of relativity. As result an intense photon beam induces for itself in vacuum some kind of gradient waveguide, which can be considered as a 2D gravitational potential well for photons. The photon trajectories in such a well become periodic with finite transverse deflection from a longitudinal axis, just like in known optical dielectric waveguides.

We present the detail solution of this selfconsistent nonlinear problem in the case of paraxial propagation of a single-mode wave in own weak gravitational field. Effect of self focusing exists, if the total EM energy of a beam exceeds the critical Planck's energy ($\sim 10^{10}$ J) and a coherence length is much longer than a beam diameter.

This new effect of divergence free propagation of EM waves in vacuum, leading to formation of photon jets in free space, may be of interest, in particular, for exploration of some cosmological problems.

TuQ26

COHERENT SCATTERING OF MULTI COMPONENT OPTICAL RADIATION ON A SINGLE ACOUSTIC WAVE.

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It is well known that the scattering process of optical beam on the single acoustic wave is amenable to law of phase synchronism followed from momentum conservation law for photon-phonon interaction. In the case of Bragg regime of diffraction taking place in isotropy media this law can be written as sinQb = l/2L, where Qb is Bragg angle, t.e. the angle between the incident light and the front of acoustic wave, L is the acoustic wavelength, l is the wavelength of optical beam propagating in media. This process similar to the light scattering on the "thick" hologram grating. From this equation follows the fact that two optical beams with different wavelengths l1 and l2 cannot simultaneously diffract on the single acoustic wave with wavelength L at the same angle Qb. In other words the changing of *l* causes to change Qb or L. Our investigations show that bichromatic optical radiation with arbitrary wavelengths l1 and l2 can diffract on the single acoustic wave when they interact in anisotropy media. Theory of such diffraction is developed. Principal theoretical results are experimentally confirmed with using of two brightest beams generated by Ar-laser (l1=0.488 andl2=0.514 mcm) and diffracted on the single acoustic wave propagating through the tellurium dioxide mono crystal. Efficiency of diffraction is more than 90%. The recent studies of acousto-optical interaction in anisotropy media show that six component optical beam can diffract on the same acoustic wave. The experiments with using of six lines of Ar-laser generated in blue-green region have been made. High diffraction efficiency of six-component optical beam (more than 80%) is obtained.

18:30-20:00 **GREEN HALL**
TuR - Ultrafast Phenomena

TuR1

SUBPICOSECOND OSCILLATION OF SYNCHRONOUSLY PUMPED LiF:F_2^- COLOR CENTER LASER

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Lithium fluoride color center (CC) crystal with F_2^- CC is known to be an efficient active element of tunable lasers. Its wide luminescence spectral range and high gain cross section ($\sigma = 7\cdot10^{-17}$ cm^2) as well as long fluorescence lifetime (τ = 65 ns) are characteristics which make these color centers a good candidate for efficient mode-locking via synchronous pumping with a mode-locked pump laser. As we have shown earlier [1] due to strong overlapping of absorption and emission bands of F_2^- color centers, the pump laser wavelength is an important parameter which allows to increase gain and efficiency of LiF:F_2^- CC laser by shifting λ_{pump} to shorter wavelength.

In this report we present results on development of efficient tunable mode-locked LiF:F_2^- color center laser with optimized pumping by Kerr lens mode-locked Nd:YLF laser working at shorter 1047 nm wavelength [2]. The flash-lamp pumped pulsed Nd:YLF laser working with 40 Hz pulse repetition rate provided a train of approximately 1000 picosecond pulses with about 4 ps duration each. The LiF:F_2^- laser cavity was formed by a plane, spherical (R = 1200 cm) HR mirrors and wedged output coupler with variable reflectivity. The laser was pumped longitudinally through dichroic mirror with the energy in the pulse train up to 3 mJ. Color center active element was 40 mm long with Brewster cut faces. The pulse duration was measured by a standard auto correlation setup with 1 mm thin $LiIO_3$ crystal.

The minimum pulse duration of LiF:F_2^- color center laser was measured to be 0.5 ps assuming Lorential shape of the pulse. It was obtained at 1.14 μm wavelength when the pump energy three times exceeded the threshold value and cavity length mismatch was exactly aligned. The total energy conversion efficiency in this case was about 6-8%. The results are compared with the theoretical analysis of synchronously pumped mode-locked laser with an active media which has decay time longer than the cavity round trip time.

1. T. T. Basiev, P. G. Zverev, and oth., Quantum Electronics, **27**, 574 (1997).
2. F. Lindenberger, R. Stockl, R. Launen, A. Laubereau, Opt. Commun. **117**, 268 (1995).

TuR2

Investigation of formation the stimulated Raman scattering pulses in dimethilsulphoxide (DMSO) with modified noncollinear correlation technique

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The modified noncollinear second harmonic generation correlation technique of the ultrashort pulses (USP) measurement proposed to investigate the backward/forward Stimulated Raman Scattering (SRS). The method is based on registration of the set of correlation functions at one pass of the correlator optical delay line with pulse selection about energy. The method allows to registrate the matrix, each element of which characterizes the temporal behavior of the SRS pulses in the preliminary fixed limits of the energy intervals. In most cases the result can be presented by the 3-dimensional surface in cartesian coordinate (two of them are energy-related and one corresponds to time scale). That selection is realised for two parameters (in presented results, on energy of the excitation and SRS pulses). This technique is extremely useful for the experiments which are directed to researching of the temporal behavior of USP as a function of excitation parameters. The obtained "surface of results" also illustrates the main trends and dependencies of the investigated effect at a single cycle of data collecting.

DMSO was studied with this technique. The pumping pulses had 30 ps duration and up to 5 mJ energy on 532 nm. DMSO produces an efficient first Stokes (633 nm) component in the forward/backward direction which is related with the C-H vibration (1000cm^{-1}). Very intensive backward Stokes component is generated with the phase conjugation. This process is highly efficient, and we consider one as a good source of the stable USP with subpicosecond duration. It was possible to measure the set of correlation functions for the forward and backward SRS (1-3 ps) pulses and to study the temporal evolution of the forward and backward SRS pulses. The shortest backward SRS pulses (about 200 fs) were produced in the near threshold conditions. Under the more intensive excitation the satellites with the picosecond-order duration appeared.

The obtained results confirm the existance of soliton-like pulses of subpicosecond range in backward SRS in DMSO.

5 Зак. 208

TuR3

Compression of femtosecond laser pulses: specific features and ultimate possibilities.

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The interest to the problem of the compression of femtosecond laser pulses has been motivated by the recent experiments [1]. In these experiments the Ti:sapphire laser pulses of initial duration of 13 fs at 780 nm and energies of the order of 30 nJ were self-phase modulated in a 3-4 mm long single-mode fiber waveguide, and then compressed up to 5 fs with the use of a *prism-grating compressor.*

The drastic decrease of duration of the input pulses and significant increase of their peak power requires reviewing *the theory of fiber-grating compression developed mainly* in the middle of the 1980-s for pico and subpicosecond pulses [2]. In this presentation we use a model based on an extended *nonlinear Shroedinger* equation describing evolution of the pulse complex amplitude. In that equation in addition to the instantaneous electronic component we have taken into account the nonstationary Raman component of nonlinear response, nonlinear group-velocity dispersion and the linear dispersion of the second and third order.

The computer simulated results obtained with the parameter values close to the experimental ones [1] made it possible to analyze a rather complicated physical nature of the laser pulse self-action. It was found out that at the initial interval of propagation it is the nonlinear dispersion of the group velocity that plays the main role and leads to the self-steeping of the pulse trailing edge. Then the optical wave breaking [3] was observed in the region of the pulse trailing edge. If the cubic dispersion is taken into consideration, the wave breaking gives rise to intensive generation of gray solitons [2] on the envelope of the broad pulse and causes significant distortions of linearity of pulse frequency modulation, thus restricting compression in a prism-grating compressor. The increase of *the input pulse power* stimulates and accelerates the above mentioned process. The results of computer simulation are in good agreement with the known *experimental data.*

REFERENCES

1. A. Baltuska, Z. Wei, M.S. Phenichnikov, and D.A. Wiersma, "Optical Pulse Compression to 5 fs at a 1-Mhz Repetition Rate" Optics Letters, **22**, 102 (1996)

2. S.A. Akhmanov, V.A. Vysloukh, A.S. Chirkin, *"Optics of Femtosecond Laser Pulses"* (American Institute of Physics, N.Y., 1992), Chap. 4.

3. W.J. Tomlinson, R.H. Stolen, A.M. Johnson, "Optical wave breaking"Optics Letters, **10**, 457 (1985)

TuR4

MECHANISMS OF SATURATION IN PULSE PROPAGATION THROUGH BULK SEMICONDUCTOR ABSORBERS

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We accomplished numerical studies of subpicosecond and picosecond pulse propagation in bulk semiconductor absorbers. The modeling showed that carrier cooling and heating influence very much saturation dynamics and pulse shaping in bulk absorbers. Carrier cooling takes place in absorbers without electric field in absorbing region, and leads to strong additional fast saturation of absorption. The saturation causes substantial decrease of saturation energies for subpicosecond pulses in comparison with picosecond pulses. Comparison of bulk and quantum well absorbers showed that the fast temperature saturation can be stronger in bulk absorber, so bulk saturable absorber can appeared to be preferable for usage in modelocked solid-state lasers. Applying nonzero electric field to bulk absorber leads to strong carrier heating, and to suppression of saturation of absorption. Saturation of absorption in this case involves such a new mechanisms as screening of the electric field by photogenerated carriers, and carrier cooling due to carrier phonon interaction and by generated cold carriers. This carrier heating by electric field leads to increase of saturation energy of absorber, and the saturation energy increases with applied electric field in absorber. The increase of saturation energy allows one to shorten power picosecond pulses without increase of length of saturable absorber, and could be used in modelocked and Q-switched semiconductor lasers for generation of power pulses.

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TuR5

SELF-ACTION OF CONTINUUM SPECTRUM FEMTOSECOND PULSES

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The self-action of femtosecond laser pulses with spectrum width ($\Delta\omega$) *comparable with* the frequency mean $<\omega>$, $\Delta\omega \sim <\omega>$ *in nonlinear transparent isotropic* media is *theoretically analyzed.*

Firstly, the nonlinear dynamic of extremely short pulses with duration up to a few periods of the light field and ultrabroad spectrum is investigated. Nonlinear propagation of extremely short pulses is treated by solving the wave equations derived for the pulse electric field (not for the slowly varying envelope) [1,2]. It is shown that the spectral ultrabroadening is the main self-action effect of pulses with the spectrum in the normal group dispersion region of the media. The possibility of the supercontinuum *spectrum* pulses time compression to light *formations of a single field oscillation* is demonstrated. *The peculiarities of solitons forming* and their interactions - the main self-action effects of pulse with the spectrum in the abnormal group dispersion region of the media - are investigated, too. The changes in spectrum of extremely short pulses and in their polarization in nonlinear reflection are studied.

Secondly, the spectral supercontinuum generation (SSG) accompanying the nonlinear propagation of femtosecond pulses with duration up to 100 oscillations of electric field is investigated. The nonlinear equations which *characterize the evolution of intensive femtosecond pulse spectrum in* transparent isotropic medium with pure electronic (self- and crossphase modulation) and both electronic and electronic-vibration nonlinearities (stimulated Raman scattering) are derived. The time compression optimal conditions of the supercontinuum spectrum pulses are determined and the possibility of 20-fold time compression of SRS and SPM pulses is demonstrated. The numerical simulation results are compared with the experiments in ultrabroad generation and compression.

1. Azarenkov A.N., *Altshuler G.B., Kozlov S.A. Self-action* of extremely shorts light pulses in dielectrics. - Proc. SPIE, 1991, v.1841, p. 2-12.
2. Kozlov S.A., Sazonov S.V. Nonlinear propagation of optical pulses of a few oscillations duration in dielectric media. -Zh.Eksp.Teor.Fiz., 1997, v.111, p.404-418.

TuR6

ULTRASHORT PULSE CHARACTERISTICS IN CW SOLID-STATE LASER WITH SEMICONDUCTOR SATURABLE ABSORBER IN THE PRESENCE OF SLOW AND FAST NONLINEAR REFRACTION

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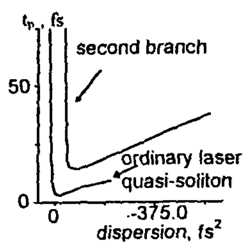
Over the past years the considerable progress has been achieved in the generation of the femtosecond ultrashort pulses. This progress was based on the use of fast electronic phase nonlinearity, which causes the Kerr lensing in the active medium and has response time closed to few femtosecond [1]. *We investigate the ultrashort pulse* characteristics and the pulse stability conditions in cw solid-state laser in the presence of the fast self-phase modulation (SPM) in the active medium and the slow SPM in the semiconductor absorber. The analysis is based on the *self-consistent field theory.* As calculations shown, the laser *pulse parameters are transformed* essentially by defocusing nonlinearity in the semiconductor. In this case there appears another branch of soliton-like solution for the laser equation (see Fig., where the dependence of pulse width t_p versus *normalized group velocity dispersion is shown). The chirp for new type solution is* small and is opposite on sign to that one for the ordinary laser quasi-soliton. The energy of the second type pulse is smaller, that produces less deep loss saturation *and leads to pulse* stability. The main features of this type of solution are the strong Stokes shift of the pulse due to slow SPM and existence of the *minimal negative dispersion producing ultra-short pulse* generation. The contribution of the semiconductor's nonlinear refractivity stabilizes the pulse in the wide dispersion region, so *that the extremely short pulse durations can be achieved over the full region of the cavity* stability. The corresponding pulse stability region is much wider than the stability region for soliton-mode locking due to fast SPM in active medium [2].



[1]. Spence D.E., Kean P.N., and Sibbett W., *Opt. Lett.* **16**, 42 (1991).

[2]. Kärtner F. X., Jung I.D., and Keller U., *IEEE J. Selected Topics in Quant. Electr.* **2**, 540 (1996).

TuR7

COLLINEAR AND NONCOLLINEAR PARAMETRIC GENERATION AND AMPLIFICATION OF FEMTOSECOND PULSES IN THE VISIBLE AND NEAR INFRARED SPECTRAL RANGE

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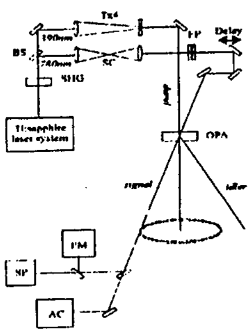
We investigate one pass noncollinear parametric generation and amplification in BBO crystal by seeding with femtosecond white light continuum.



The pump source for our OPO and OPA experiments was 1-kHz repetition-rate double-frequency Ti: sapphire laser system with 200 fs-duration, 0.3-mJ energy at 390 nm pulses. For OPA we used a 1.5-mm-thick BBO I-type crystal, cut at Θ=31°. As a seed signal, we used supercontinuum from fundamental beam focused into 5-mm-thick fused silica block. The duration of the seed pulses was measured to be 200 fs. When only the pump pulses were applied to the BBO crystal, then the parametrically-generated signal and idler waves observed at the output of the crystal as two cones. Our calculations show that this cones is determinated by group velocity matching conditions for noncollinear OPO. When the pump and seed pulses were applied to BBO, then besides rings a bright spot in the direction of the seed beam was observed. The noncollinear parametric process amplified efficiently only these wavelength components, where the seed pulse had the same propagation direction as the corresponding spontaneously generated beam. An amplification factor of 10^9 is achieved at the wavelength of 560 nm for 10^{-15} J pulses.

TuR8

ULTRAFAST OPTICAL PROCESSES IN NEW Cu-Fe-S NANOPARTICLES

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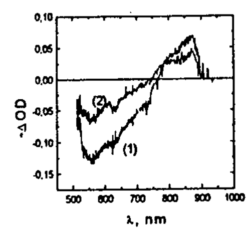
Nanometer size semiconductor particles are of particular interest because of their nonlinear optical applications. The presence of the particle surface as a boundary and source of surface states makes optical properties of nanometer-sized particles highly sensitive to chemical treatment of ones. In this presentation, we report the results of picosecond pump-probe measurements on $CuFeS_2$ and $CuFe_2S_3$ nanoparticles with and without oxidation of their surfaces.

The newly synthesised Cu-Fe-S particles with and without oxidation of their surfaces used in this study had a mean radius of 3-5 nm. In the pump-probe experiments we have used the 15 ps duration pulses at 1.08 and 0.54 μm as a pump beam and the picosecond white-light continuum - as a probe beam.

Absorption spectra of oxidized Cu-Fe-S samples demonstrate an additional broad band peaked at 1.1 eV and an absorption edge rising from ~2.5 eV. This edge is related to the fundamental absorption in Cu-Fe-S nanoparticles.

Bleaching of additional absorption band in oxidized Cu-Fe-S nanoparticles was achieved (Fig.). The kinetics of bleaching of near IR absorption band and induced absorption has biexponential type with rather short τ_1 characteristic time of ≈30 ps.



Mechanism of nonlinear effects relaxation, energy level diagram and possible applications of Cu-Fe-S semiconductor nanoparticles in nonlinear optical devices are discussed.

Figure. Differential absorption spectra of oxidized $CuFeS_2$ nanoparticles under 15-ps 1.08 μm laser excitation at different delay times: 20 (1), and 150 (2) ps.

TuR9

THE NONLINEAR DYNAMICS IN THE INTERACTION OF ULTRASHORT LIGHT PULSES WITH THIN-FILM CAVITY STRUCTURES

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The cavity's model of the Fabry-Perot type has the evident advantage in a view of physical simplicity, and can be used to research a number of phenomena in coupled resonant systems such as generation of radiation in lasers, optical bistability, soliton formation, dynamic chaos etc.

In the paper the nonlinear dynamics in the interaction of an ultrashort light pulses with the resonant structure of the Fabry-Perot cavity containing resonant atoms has been investigated /1,2/. The problem can be reduced to the solution of dynamic equations for the field in the cavity and for the quantum oscillator /2/. The numerical integration was used in execution of following conditions: $L/c \ll t \ll T_2 \ll T_1$, where L and t are the cavity length and the characteristic duration of light pulse, and T_2 and T_1 are the times representing the homogeneous broadening of the spectral line and the life-time of the excited atoms /3/.

In the frame of considered task (with the characteristic time T_2^*, which corresponds to the inhomogeneous broadening of the energy levels of an resonant atoms) the calculations of excitement parameters which permit to model the evolution of the state of the medium inside the cavity and also an output light pulse $e(\tau)$ ($\tau = t/T_2^*$), for a given input pulse $e_0(\tau)=A\eta/ch(\eta\tau)$ have been performed.

Numerical calculations for 4π-pulses were used as example to illustrate the split of the response of an resonant system into two subpulses with characteristic delay time: $\tau_0+(\tau_0+1/\eta)\ln|(\eta+1+C)/(\eta+1-C)|$, where C and τ_0 are the some nonlinear parameter and photon lifetime in a cavity. Such an evolution of the response of a cavity structure is associated with the inhomogeneous broadening of the absorption line and reminds of qualitatively the transformation of a signal in thin film /4/. The subsequent transformation of such peaks (with increasing of τ_0) reduces mainly to the separation of the soliton-like 2π-pulse in the first subpulse.

The appearance of superradiance, which occurs when the intensity is increased and the characteristic duration is reduced, can exist for $C > 1+\eta$ in the first subpulse.

REFERENCES

1. S.M.Zakharov, E.A.Manykin. JETP, 1994, **78**(4), 566-571.
2. S.M.Zakharov. JETP, 1995, **81**(3), 452-458.
3. V.A.Goryachev, S.M.Zakharov. Quantum Electronics, 1997, **27**(3), 245-248.
4. V.I.Rupasov, V.I.Yudson. JETP, 1987, **66**, 282.

TuR10

AN INVESTIGATION FOR ATTENUATION AND SCATTERING OF SHORT-LASER PULSES IN A STRONGLY SCATTERING MEDIUM

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The relationship between the nature of the attenuation of light and the duration of the probe laser pulses were investigated on the basis of the dependence of the optical density ***D*** on the thickness h of a model strongly scattering solution with a range of concentrations *C*. There were used the probe laser pulses sufficiently short to avoid possible photochemical and thermal effects of light on the parameters of the medium. Measurements were carried out in the near-IR range since this part of the spectrum is most promising for the investigation of the effects of light on strongly scattering biological tissues as a result of weaker attenuation inside these tissues.

There were used a single-mode monopulse Q-switched neodymium glass laser with a single pulse of 20 ns duration; Nd: YAG laser with hybrid longitudinal mode locking and passive intracavity feedback (τ = 10 ps); Ti: Al_2O_3 laser with regenerative amplifier of the radiation energy (τ = 120 fs). A model scattering medium was a solution of dry milk in water, placed in rectangular glass cells of various thickness *h*. The angular size of an aperture in front of the detector of the transmitted light determined the measured proportion of the forward-scattering radiation. The temporal characteristics of the transmitted light were recorded by a linearly scanning streak camera with a maximum temporal resolution of 1.5 ps [1].

For a quantitative description of received results simultaneously in the ranges of action of the ballistic and scattered photons one could use the following expression for determination of the transmission coefficient $T(h)$ of a layer h of a strongly scattering medium

$$T(h) = (1-\beta)\exp(r_1 h) + \beta r_2 / [r_2 \cosh(r_2 h) + r_1 \sinh(r_2 h)] \qquad (1)$$

The coefficient β in the above expression takes account of the finite angular aperture of the radiation detector. The values of β are obtained for various experimental conditions.

Our results showed that expression (1) can be used to describe the dependence of the transmission of a layer of a strongly scattering medium on the parameters of this medium when detectors of finite angular aperture are used. The absorption and scattering coefficients were found for a model water-milk solution from the measured energies of short (from nanosecond to femtosecond) laser pulses. A fairly strong anisotropy is observed for short pulses scattered forward.

This work was supported financially by the Russian Basic Research Foundation (project No. 96-02-18900).

1. N.S.Vorob'ev, V.M.Podgaetsky, A.V.Smirnov, S.A.Tereshchenko. Kvantovaya Elektronika, 1997, v.24, N 7, p.667-670.

TuR11

DYNAMICS OF LIGHT-INDUCED ANISOTROPY IN CU-PORPHYRIN SOLUTIONS STUDIED WITH CORRELATION INCOHERENT-LIGHT TECHNIQUE

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Transient spectroscopy technique based on correlation properties of broad band-width light has been applied for studying orientational diffusion of Cu-octaethylporphyrin (Cu-OEP) and Cu-tetraphenylporphyrin (Cu-TPP) dissolved in tetrahydrofuran (THF). It is known that excited Cu-porphyrin molecules form complexes with such coordinating solvent as THF.

The Kerr-shutter scheme of degenerate four-wave mixing was realized. The second harmonic of Nd:YAG laser was used to induce optical anisotropy in a sample. Its first Stokes component of stimulated Raman scattering in compressed hydrogen or barium niobate crystal served as a probe beam. The pump and probe radiations were correlated and characterized by the correlation time of 33 ps.

Two mechanisms contribute to the measured anisotropy: the population of excited states and orientation of molecules. It is known that during nanosecond-pulse excitation the relatively long-lived triplet state T_d can be quasi-stationary populated. If the frequency of the probe beam lies near the triplet absorption band, molecules in the mentioned T_d state may contribute to the induced anisotropy.

The orientation-diffusion constants were obtained from fitting experimental and calculated curves under assumption that noisy laser light was described as stationary stochastic Gaussian process. We found that both Cu-OEP and Cu-TPP in THF had 120 ps orientation-diffusion time accounting for their ground-state population recovering times of 360 ps and 190 ps, respectively. As we observed similar signals when the probe field is near or far from the singlet-state resonance, we attribute measured diffusion constant to the excited T_d state. Because the measured constant is typical for this solvent, one can see that complexation does not influence substantially the orientation motion of Cu-porphyrins in THF.

TuR12

Spectral and Temporal Characteristics of Laser Pulses in the Stretcher-Compressor Systems

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Chirped-pulse amplification systems are widely used to produce terawatt femtosecond laser pulses[1]. In such systems femtosecond seed pulse is first expanded to much longer duration in a stretcher and after amplification is compressed back to short duration. The pair of stretcher-compressor should ideally produce a transform-limited femtosecond pulse. In practice high-order phase distortions due to dispersion in both amplifier and stretcher-compressor elements prevent from achieving this result.

In theory one can calculate residual phase distortion by the ray-tracing method. Within the framework of this method a pass of each spectral harmonics of an input pulse through optical elements of the stretcher-compressor and the amplifier is calculated. The pulse form is reconstructed at the output of the system with regard to calculated delays of the pulse's spectral components.

We have developed a software program to calculate spectral and temporal distortions of ultrashort laser pulses in optical systems, typical for stretcher-compressor design. Phase shift of the pulse's spectral harmonics obtained by ray-tracing method for 25-fs transform-limited pulse is shown in Fig.1. It was used to reconstruct pulse shape (Fig.2). The pulse is wider than at the input and has a long tail. The program can be used to optimise parameters of the system.

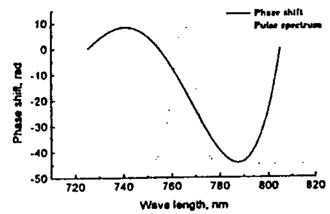

Fig.1. Phase shift of the spectral harmonics with overall tilt excluded. Dashed line - pulse spectrum.

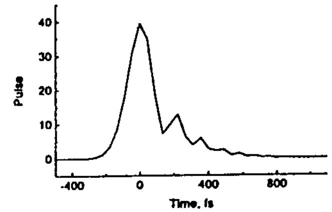

Fig.2. Pulse form at the output of the compressor, a.u.

REFERENCES

1. M.P. Kalashnikov, G. Sommerer, P.V. Nickles, W. Sandner, Kvantovaya Elektronika, Moskva, 24, 415 (1997).

TuR13

EXCITATION OF ATOM IN TARGET STATE BY HIGH-POWER PULSES OF LASER RADIATION

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Exciting atoms in target energy state is important, desirable but difficult problem. It is necessary for spectroscopy studies, for investigating relaxation collision atom processes, for chemical reaction control and so on. The method for selective exciting atoms must be both effective to get considerable quantities of atoms and fast to overcome relaxation processes. These conditions can be satisfied with effect on an atom by high-power short pulses of laser radiation with proper frequencies to realize resonance excitation. Such coherent mechanism was introduced and investigated to excite molecular vibration states selectively.

In this paper a mechanism for coherent selective ultrafast excitation of atom is considered. The simulation shows the necessary parameters values of pulses are about 10^{-13} s, 10^{8} W/cm^2. If the frequencies are chosen correctly the most of all atoms occurs in target state at the end of the process. This regime can be realized at modern day level of laser engineering. Li atom is simulated as an example. The pulse with 700 nm wavelength and 0.5 ps duration is necessary to prepare the atom in 3d state from general 2s state. There are 90% Li atoms in the target state with empty intermediate 2p level and with 10% population of 2s level in the end of pulse. Exciting the atoms by two pulses with more low intensity one can obtain 60% atoms in 3d state in the end of the first pulse and 95% — after the second one. To excite the atom in more high levels several pulses with different frequencies can be used.

Every frequency must be obeyed two-photon resonance condition. In addition proper intensity and duration of every pulse must be fit. The first pulse transfers the atom from 0 to 2nd level and the second pulse populates 4th level. The two-frequency two-pulse coherent method gives new possibility (non-investigated and non-realized still) to prepare atoms in excited target states with high selectivity and efficiency. This coherent method can produce exciting and selection of atoms very fast. The disadvantages of the method are the high power short pulses have to be used.

TuR14

ULTIMATE QUANTUM EFFICIENCY AND PERFORMANCE OF NBN SUPERCONDUCTING HOT ELECTRON PHOTODETECTORS

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We report our studies on the photoresponse of ultrathin, micron-size NbN superconducting hot electron detectors (HED). We have found that the responsivity (A/W) of the HED doesn't depend on the signal wavelength from the far IR to the UV range, and can be at least two orders of magnitude higher than that measured for comparable semiconductor optical detectors. The latter have already reached a nearly 100% quantum efficiency, and they are, without some active gain mechanism, as, e.g., in photomultipliers, incapable of yielding higher responsivities. At the same time, the HED may reach far better performances, due to their low values of the superconducting energy gap Δ, and the fast and very effective multiplication of photo-excited carriers (quasiparticles). The quantum efficiency of the HED device is determined by the number of the newly generated excess quasiparticles, which may reach $N_{max}=\hbar\omega/\Delta$, while the performance is limited by the cooling time of the electron subsystem, combined with the escape time of the nonequilibrium phonons from the film into the substrate. We have measured the photoresponse of 5-nm-thick NbN structures to the radiation from a semiconductor laser with the wavelength of 780 nm. The detector was irradiated through a matched optical fiber and the output signal was brought out via a microstrip line. In our experiments, the responsivity of the detector, normalized to its illuminated area and the coupling factor, was 300 A/W, which corresponded to the quantum efficiency of $N_{max} = 460$. The time constant of the photoresponse signal, which was measured using a cryogenic electro-optical sampling technique of subpicosecond resolution, was 45 ps. The obtained results agree with our calculations, performed using a two-temperature model of the electron heating in thin superconducting films.

This research was partially supported by the U.S. Office of Naval Research grant N00014-97-1-0696.

TuR15

FEMTOSECOND PULSES FORMATION DYNAMICS IN A PULSED SYNCHRONOUSLY PUMPED TI:SAPPHIRE LASER

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Since 1991, pulses of sub-100 fs duration which are widely tunable in the near-infrared have become available on the basis of Ti:sapphire lasers by using different mode-locking techniques [1]. To date, practically in all experiments gas or solid-state cw lasers were used as a pump source. Recently we have demonstrated the simple and reliable pulsed all-solid-state laser system capable of generating sub-100 fs pulses [2]. The system has relax stability requirements and low cost (compared with well-known cw-modelocked lasers). Nevertheless limited time interval (~30 μs), being available in this case for start of the Kerr Lens Mode-locking (KLM), puts forward special requests to a construction of Ti:sapphire laser.

In this paper we report on experimental studies of femtosecond pulses formation dynamics in a pulsed synchronously pumped KLM Ti:sapphire laser. The optimum resonator parameters are derived with the help of theoretical analysis based on nonlinear ABCD matrix formalism, conditions of pulsed synchronous pumping being take into account.

As a pump source, feedback-controlled passively mode-locked Nd:glass laser was used. The output of the Ti:sapphire laser has the same duration as the pump train. Experiments have shown that KLM buildup times are about 5-10 μs depending on pump level. In accordance with observable effects it is possible to distinguish at least four temporary stages in femtosecond pulses formation process. At the beginning nearly free running operation takes place, when the conditions for KLM are created due to synchronous pumping. Then dramatic spectral changes proceed during approximately 3μs, which are accompanied by strong modulation of output envelope. Envelope becomes smooth, however during 2-5 μs a spectrum continues to be transformed up to the stationary level. The tail part of the output is a time domain of quasi steady-state generation of femtosecond pulses. The pulse width is about 70 fs. The spectrum full-width at half-maximum is 10 nm and the center wavelength is 785 nm. So, the pulsewidth-bandwidth product is $\Delta\nu\cdot\Delta t = 0.34$ which is close to the Fourier-transform limit of 0.32 for $sech^2$ pulses.

We will discuss the major limiting effects and possible ways of improving the system performance.

1. F.Krausz, M.E.Fermann, T.Brabec et al. IEEE J.Quantum.Electron., V.28, 2097, (1992).
2. N.A.Borisevich, O.V.Buganov, S.A.Tikhomirov, G.B.Tolstorozhev. Quantum Electronics, V.26, 978, (1996).

18:30-20:00 **BEIGE HALL**

TuS - Quantum and Atomic Optics

TuS1

Thermodynamics of Bose-Atoms in One and Two Dimensional Dark Magneto-Optical Lattices

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The motion of atoms with a $1 \to 1$ transition in a dark magneto-optical lattice is considered. This lattice is formed by strong laser field due to the coherent population trapping (CPT) in the presence of a static magnetic field [1]. It is shown that in special field configurations under the laser cooling temperatures (10^{-4} – 10^{-6} K) atoms freely move along isolated planes or lines with small transverse deviations, that is much less than the light wavelength. Thus, in magneto-optical potentials one and two dimensional structures are effectively formed in a rare gas. The thermodynamics of a degenerated ideal gas is applied to a study of the Bose-Einstein statistics effects in such structures. The possibility of a phase transition under $T \sim 10^{-5} - 10^{-6}$ K and the usual densities 10^{10} – 10^{12} cm^{-3} is demonstrated. We find the field configurations, where the form of themagneto-optical potential do not depend on phases of laser waves.

The obtained results can be generalized on all CPT-transitions, i.e. $F \to F\text{-}1$ and $F \to F$ with F an integer.

[1] N.P.Konopleva, A.V.Taichenachev, A.M.Tumaikin, V.I.Yudin, Quantum Semiclass. Opt., V.8, P.837 (1996).

TuS2

Trapping of Atoms in a Dark Magneto-Optical Lattice.

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A magneto-optical lattices for trapping of cold atoms in nearly dark state have been proposed [1] and experimentally demonstrated [2]. This lattices are characterized by a weak interaction of localized atoms with optical field in the result of the coherent population trapping (dark lattices). Here we present a dark magneto-optical lattice to confine atoms with a $J_e = J \to J_g = J-1$ transition, where J_e, J_g are the angular momenta of the ground and excited states. As distinct from a $J \to J$ atomic transition considered in [1,2] there are two dark in elliptically polarized laser field in this case. One dimensional periodic potential is obtained with the σ^+-σ^- or *lin* ⊥ *lin* laser field and a uniform magnetic field orthogonal to the light waves propagation (in the case of *lin* ⊥ *lin* laser field a magnetic field have to directed along the π - polarized field component). Minima (maxima) of the magneto-optical potential correspond to space points, where the dark states does not destroy by the magnetic field. We have demonstrated the sub-Doppler cooling and the dark or gray atomic lattice formation for a $1 \to 0$ transition in the case of a blue detuning of the laser field. The temperature dependence on the magnetic field have been investigated and comparison with dark atomic lattices in a longitude magnetic field [3] was carried out. \vspace{0.5cm}

REFERENCES.

1. G.Grynberg and J.-Y. Courtois, Europhys. Lett., V.27, 41 (1994).
2. A. Hemmerich, *et. al.*, Phys. Rev. Lett., V.75, 37 (1995).
3. K.J.Petsas, J.-Y.Courtois, G.Grynberg, Phys. Rev., 53, 2533 (1996).

TuS3

Local-field effect and interaction of dense Bose-Einstein condensate with electromagnetic field

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We have developed the quantum theory of the interaction of ultracold atomic ensemble with the electromagnetic field of vacuum and laser photons. The main attention is paid to the consistent consideration of dynamical dipole-dipole interactions. We show that retardation effects influence significantly the behaviour of the atomic ensemble in the radiation field.

The ensemble of ultracold atoms is described as a two-component vector field $\psi(\mathbf{r},t) = \psi_g(\mathbf{r},t)|g\rangle + \psi_e(\mathbf{r},t)|e\rangle$, where $|g\rangle$ and $|e\rangle$ are the state vectors of the ground and excited states of the quantized atomic field; ψ_g and ψ_e are annihilation operators of the atoms in the internal states $|g\rangle$ and $|e\rangle$, respectively.

Theoretical analysis carried out under consideration of local-field effect leads in adiabatic approximation to the following system of equations:

$$i\hbar\frac{\partial\psi_g}{\partial t} = \left\{-\frac{\hbar^2\nabla^2}{2m} + \frac{\hbar}{4}\frac{\Delta - i\gamma/2}{\Delta_l^2+\gamma^2/4}\left|\Omega^+\right|\right\}\psi_g \quad ,$$

$$\Delta_l = \Delta + \frac{4\pi}{3\hbar}\mu^2\psi_g^\dagger\psi_g \quad , \quad \Delta = ck_L - \omega_a - \delta \quad , \tag{1}$$

$$\nabla^2\Omega^+ + k_L^2\Omega^+ = 2\sigma_l k_L\left(\frac{\Delta_l}{\gamma} - \frac{i}{2}\right)\psi_g^\dagger\psi_g\Omega^+ \quad ,$$

$$\sigma_l = \frac{\gamma^2}{4\Delta_l^2+\gamma^2}\sigma_{peak} \quad , \quad \sigma_{peak} = \frac{3\lambda_L^2}{2\pi} \quad ,$$

where γ is the spontaneous emission rate of a single atom in free space, δ is the Lamb shift of a single atom induced by the vacuum electromagnetic field, ω_a is the frequency of atomic transition, μ is the matrix element of atomic dipole moment, k_L and λ_L are the wave number and the wave length of the laser radiation.

The general system of equations (1) may be used for the investigation of various linear and non-linear phenomena in atom optics at arbitrary densities of the atomic system. As an example, we have considered the Bragg scattering of ultracold atomic beam by the standing laser wave. We show that with the increase of the initial density the intensities of Bragg resonances decrease.

TuS4

Cold Trapped Molecules

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Abstract

There have been many demonstrations of the production of laser cooled and trapped neutral atoms. We will present our results concerning the production and trapping of cold cesium molecules. We have produced 10^8 cold cesium atoms using a magneto-optical trap (MOT). We have also demonstrated that a focussed CO_2 laser can be used to form a quasi-electrostatic trap (QUEST) and confine up to a million cesium atoms. The confining potential can be described by $U = -\alpha E^2/2$, where α is the polarizability of the trapped specie and E is the laser electric field. A focussed 20W CO_2 laser can produce a 500μK confining potential for cesium molecules. We will be using an additional laser to photoassociate the cold atoms to form cold cesium molecules. These molecules will be loaded and confined in the QUEST. Cold trapped molecules can be used in a variety of applications including molecular optics, spectroscopy, microwave and laser frequency standards.

TuS5

Atom Beam Splitters Based on Raman Transitions in Continuous Light Waves

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Coherent splitting of atomic matter waves is one of the important tasks of atom optics. Recently, an atomic beamsplitter using a two-level atom driven by two spatially phase shifted, differentially detuned standing waves has been proposed [1]. This beamsplitter gives very clean splitting, but its efficiency is very much limited by spontaneous emission. We propose two new configurations for the beamsplitter based on three-level Raman atom-light interaction scheme. In first scheme, the far off-resonance bichromatic standing light wave and a superimposed traveling light wave form a Raman resonance between two sublevels of the ground state of atom. The second scheme uses two spatially shifted pairs of far off-resonance bichromatic standing light waves. The main advantage of the schemes is that the population of the excited state of the atom can be very small. Therefore the probability of interrupting the coherent de Broglie wave splitting by spontaneously emitted photons is very low. These properties of the beam splitter allow to apply it for all alkali atoms with strong transitions including the case of very slow atoms. We have calculated the transverse momentum distributions of the split beam of Cs atoms for different parameters of the light fields and different interaction times. It is shown that the absolute magnitude of the momentum splitting can be as large as few hundred photon momentum.

This work is supported by the Austrian Science Foundation under project No. S 6508.

[1] R.Grimm, J.Söding, and Yu.B.Ovchinnikov, Opt. Lett. 19 (1994) 658.

TuS6

APPLICATION OF NEW TYPE EFFICIENT BEAM SPLITTER FOR THREE - LEVEL ATOMS TO MATTER - WAVE INTERFEROMETER

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There are a few proposals for coherently splitting of an atomic beam into different transverse momentum components for the realization of an atom wave interferometer [1]. The beam splitter is efficient if incoming atomic beam after interaction with the light waves splits into only two components , which can be separated by a large momentum. In recent years one of the suggested schemes (the interaction of two level atoms with two standing waves, having the «mirror» detunings [1]) allows to obtain only two coherently components in the outgoing atomic beam. In this case the momentum scale of splitting is increasing in time. The main lack of such interaction scheme is that the atoms have to prepare in defined superposition, which consists from lower and excited state, and also both initial and finite superposition state decay.

In our message we consider the new type of three-level atom beam-splitter, which is based on the interaction of the three level atoms with the field of four standing waves, having different phase shift in space. It is shown that this type of beam-splitter allows to obtain large clean angle splitting in the momentum space. Besides, the atoms after interaction with optical field are only in lower (stable) atom states. Moreover in this case the number of atoms into two coherent components is much large than for the case of three-level atom coherent scattering in two shifted standing waves with mirror detunings. At last the efficiency of our beam-splitter is very close to the case of two level atom, interacting with two standing shifted waves. Note that for the three level atom scheme we are shown that the formation time of very clean splitting is faster than for two level atom case.

We investigate also the first-order coherency property of such beam splitter, which is an important test of its usefulness in atom-wave interferometer. We find that the beam-splitter shows maximum visibility value of 0.4. We propose a new type of atom interferometer based on the interaction of three-level atom with the field of four standing shifted waves. It is important point that in our case the atom wave interferometer can be realized experimentally more easily then for the case of using two-level atom beam-splitter [2] because during the free flight the atom number does not lose.

1. S.M.Tan, D.F.Walls «Analysis of the bichromatic beam splitter», *Opt.Commun.* 118 (1995) 412

2. S.Choi, H.M.Wiseman, S.M.Tan, D.F.Walls «Coherence of the two-level atom bichromatic beam splitter» *Phys.Rev.*, A55, N1 (1997) 527

TuS7

ANOMALOUS DIFFRACTION OF THREE-LEVEL ATOMS IN STRONG STANDING WAVES

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In the recent experiments [1] on scattering of atoms in the strong resonant field of a standing wave unexpected anomalies contradicting known representations of coherent atomic scattering in the standing wave field were observed: an asymmetry of the momentum distribution of scattered atoms and an oscillatory character of the frequency dependence of the scattering amplitude. It was established that the oscillations of the scattering amplitude and asymmetry of the scattering diagram occur with an identical characteristic frequency, which is not a function from the field intensity or the observation angle [1].

The principal explanation of this anomalies was given in [2] on the basis of two-level atoms. A hypothesis was put forward that the peculiarities may be caused by the state of the atom in the moment of the standing wave establishment, caused by the preliminary excitation of atoms by a running wave. It was shown that for specific mixed initial states (for which the ground and excited levels differ on the momentum) in which the atom appears at interaction with a running wave (provided a sharp inclusion of the interaction) the diffraction of atoms by a strong standing wave occurs asymmetrically and oscillatory.

In the present paper, we first review the proposed model theory of anomalous scattering in the field of a standing wave for two-level atoms. Then we consider the peculiarities of the anomalous scattering of atoms in the three-level case which recently attracts especial attention in the context of diverse possible applications in the quantum optics and atomic interferometry.

We examine the opportunities for the development of effective beam-splitters and mirrors by means of ~~the effective engaging of three atomic levels into the~~ interaction with an external field at anomalous scattering regime. We consider the dispersion of the scattering diagram and snow that the distribution of atoms by momenta at anomalous regime displays essential narrowing of the one of the diagram peaks compared with usual case.

We display the role of new peculiarities taking place in the three-level case (the partial population trapping on certain, populated owing to the preliminary interaction with the running waves, optical-mechanical mixed states, etc.) and show the way the specified peculiarities should be correctly taken into account at choice of the effective modes of atomic selection or splitting of beams by the three-level scheme when applying successive pulses of running and standing waves with non-equal amplitudes, as, for example, at formation of pulse standing fields by reflecting mirrors.

References:

[1] G.A. Ryabenko, V.A. Grinchuk, et al., Laser Physics, v.6, p.150, 1996.
[2] A.M. Ishkhanyan, Laser Physics, v.7, no.6, p.1225, 1997

TuS8

Phase Space Imaging of Trapped Atoms Using Magnetic Sublevels Coherence

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By phase space imaging [1] one usually means obtaining the probability density for a quantum system in position-momentum coordinates. Experimental phase space imaging has become *very important area during the recent years due to advances in* laser cooling and trapping, atomic beam techniques, and especially BEC.

We present our latest experimental data and analysis for a phase space imaging technique based on a grating of coherences between magnetic sublevels of an atomic ground state. Our system is a laser trapped atomic cloud on which some structure has been imposed, e.g. the cloud was split in two with a laser pulse. The "shearing effect" of free evolution of such a system allows us to create more complex phase space structures.

The coherence grating is created by sending two optical pulses through the cloud. The pulses are simultaneous and they make a small angle θ. They drive Raman transitions between the sublevels and create a coherence grating whose period is determined by θ. Applying a weak readout pulse in the same mode as one of the excitation pulses, one sees a macroscopic signal coherently radiated by the sample into the other mode. This can be done immediately after the excitation, in which case we observe the "Magneto Grating Free Induction Decay" (MGFID), or some time $2T$ later, after rephasing the decaying coherences by the second pair of excitation pulses which follows the first one at time T. In this case we observe the "Magneto Grating Echo" (MGE).

The above-mentioned decay of the coherences is due to the Doppler phase acquired by each atom individually in the course of its thermal motion. Therefore the width of both MGFID and MGE signals reflect velocity distribution of the ensemble. The position distribution can be as well encoded in the signal frequency spectrum, if the sublevels are slightly (within the bandwidth of the excitation pulses) shifted by a position-dependent magnetic field. If this shift is on during the readout pulse, the spectrum of the MGFID signal represents a projection of the phase space density in a direction determined by the strength of the field. From a set of such projections, the phase space image is reconstructed (tomography).

Alternatively, using the MGE technique, the magnetic field pulse is applied between the excitation and the rephasing pulses and is off during the readout pulse. Then, complete information about the phase space density is retrieved by two-dimensional Fourier transformation of the data similarly to how it is done in Magneto Resonance Imaging. We compare the MGFID and MGE techniques and discuss the perspectives of our research.

[1] E.g. J.E. Thomas and L.J. Wang, Physics Reports **262**, 311 (1995).

TuS9

CHAOTIC VACUUM RABI OSCILLATIONS IN CAVITY QED: A NEW KIND OF REVERSIBLE SPONTANEOUS EMISSION

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It is known that spontaneous emission can be made controllable and *even reversible* by placing excited atoms in a single-mode empty cavity. We show that reversible spontaneous emission of moving atoms may be instable in the sense of exponential sensitivity to initial conditions. To study this effect of dynamical chaos in the fundamental interaction between matter and vacuum we derive a nonlinear dynamical system which includes interatomic quantum correlations as a source of spontaneous emission. Computing maximal Lyapunov exponents λ, we give an evidence of existing chaotic vacuum Rabi oscillations of the atomic inversion $z(t)$ for the non-resonant interaction. In Fig.1 and 2 we show the Lyapunov maps of this chaos for two atoms with $z(0) = 0$ and $z(0) = 1$, respectively, where Ω is the single-atom vacuum Rabi frequency, ω is the detuning, b is the ratio of the velocity of the atoms to the speed of light in free space. The values of λ, which characterize the strength of chaos, are shown on the maps. We have also carried out a number of numerical experiments with a large number of atoms (up to 10^6) and different initial conditions. In real experiments, the chaos may be detected by measuring the power spectrum of the intensity of spontaneous emission which should be broadened. The optimistic estimates made show that some manifestations of quantum chaos can be measured in real micromaser devices.

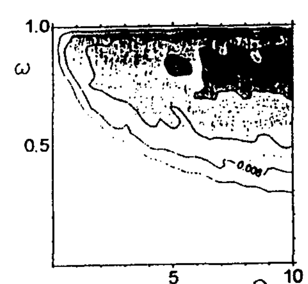

Fig.1. Lyapunov map of chaos in the vacuum-atom system for two atoms with zero initial inversion, $b = 0.01$.

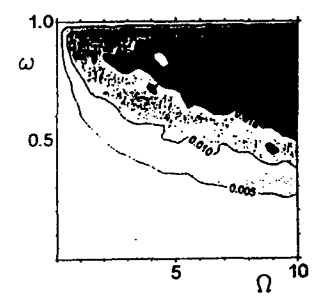

Fig.2. The same for initially inverted atoms.

TuS10

OPTICAL TOMOGRAPHY AND MEASURING QUANTUM STATES OF AN ION IN A PAUL TRAP AND IN A PENNING TRAP

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Measuring quantum states (including nonclassical states) of photons and trapped ions attracts attention last few years [1, 2]. Recently, optical tomography method [3] and symplectic tomography method [4] of measuring quantum states of a photon were suggested. The aim of the talk is to discuss tomography methods for measuring quantum states of an ion in a Paul trap and in a Penning trap.

The marginal distributions of nonlinear coherent states, nonlinear even and odd coherent states, and the Fock states of an ion in a Paul trap are given explicilty in both (optical and symplectic) tomography schemes. The marginal distribution $w(X, \mu, \nu, t)$ for an ion in a Paul trap described by the Hamiltonian $H = [(-\partial^2/\partial x^2) + \omega^2(t)x^2]/2$, $\hbar = m = \omega(0) = 1$, satisfies the evolution equation

$$\dot{w} - \mu \frac{\partial}{\partial \nu} w + \omega^2(t)\, \nu \frac{\partial}{\partial \mu} w = 0\,.$$

The Hamiltonian for a charged particle with mass m in an asymmetric Penning trap (discarding the harmonic movement with frequency ω_z along the z-axis) is

$$H = \frac{1}{2m}\left(p_x^2 + p_y^2\right) + \frac{1}{2}\,\omega_c\,(xp_y - yp_x) + \frac{1}{2}\left(\omega_x^2 x^2 + \omega_y^2 y^2\right),$$

where frequencies ω_x and ω_y are defined by the expression $\omega_{x,y}^2 = (\omega_c^2/4) - (1 \pm D)\,\omega_z^2/2$ (here ω_c is the cyclotron frequency and D, a parameter that measures the axial asymmetry).

For both models, we calculate probability distributions which determine quantum states and these probability distributions can be measured experimentally.

References

[1] S. Schiller, G. Breitenbach, S.F. Pereira, T. Muller, and J. Mlynek, *Phys. Rev. Lett.* **77**, 2933 (1996).

[2] R.L. de Matos Filho and W. Vogel, *Phys. Rev. Lett.* **76**, 608 (1996).

[3] D.T. Smithey, M. Beck, M.G. Raymer, and A. Faridani, *Phys. Rev. Lett.* **70**, 1244 (1993).

[4] S. Mancini, V.I. Man'ko, and P. Tombesi, *Quantum Semiclass. Opt.* **7**, 615 (1995).

TuS11

ANTIPHOTONS

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The paradox of the absence of the limiting transition between the interference of two classical electromagnetic field and the superposition of two fields in quantum coherent states is treated. The paradoxical properties of the quantum superpositional states are supported to be due to the uncompletness of the field spectrum and due to the physical reality of the negative-energy field - antiphoton field. The negative-energy eigenstates and eigenfunctions of one-dimentional harmonic oscillator are determined - the antiphoton states. The complete coherent states of electromagnetic field are constructed with regard to the antiphoton states. The superposition of the complete coherent states are shown to assert the limiting transition between quantum and classical description of interference. The energy sign of the field in the complete coherent state is of the clear physical meaning and is correlated with the phase of field relative to the phase of the dipole moment of ideal quantum coherent detector - the two-level atom in the superpositional state with a fixed phase and the equal population of levels. The energy sign is determined with the direction of the energy transfer: from field to atom - the field energy relative to atom is positive, or from atom to field - the field energy is negative. The Planck distribution of the number of quanta (photons + antiphotons) of the field at the fixed temperature is fulfilled if the field is registered by the ideal quantum noncoherent detector - the atom in the basic state. At the same time the energy of the thermal field beeng registered by the ideal quantum coherent detector is zero at any temperature. The crutial experiment of this theory consist in the coming to light the absence of spontaneous radiation of ideal quantum coherent detector in the black body radiation field at any temperature.

TuS12

The subpoissonian light generation of two-level single mode laser with incoherent pump

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A full quantum description of single-mode two-level laser with incoherent pump is developed by the use quantum open system master-equation for density operator in Fock-state basis. The master-equation in Fock-state basis technique for the open quantum system permits us study any regimes of lasing in two-level single-mode scheme without some standard adiabatical assumption, and for any initial states of field and atom. We analyze the dynamic of quantum statistical properties of the laser radiation. Substantial deviations from classical predictions in photon statistics (the shot noise level) are found out in stationary state when both pump and mirror decay rates are more then spontaneous emission rate. We found that the maximum value of the photons number squeezing equals 15% for the optimal values of decay and pump rates $\gamma = P = 1.4\ g \gg \Gamma$ where γ - mirror losses rate, P - pump rate, g - coupling constant and Γ - spontaneous emission rate. We show that in special range of laser parameters the transient photon number squeezing also takes place. If lasing starts from coherent vacuum field state many time photon number squeezing can be obtain in transient regime with average photon number being greater then 1 per one atom.

TuS13

POLARIZATION - SQUEEZED LIGHT IN DISSIPATIVE PERIODICALLY MODULATED CUBIC - NONLINEAR MEDIUM

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SUMMARY

During polarized wave propagation through the cubic - nonlinear medium a polarization - squeezed (PS) light can be generated. For such a light the fluctuation level of one of the Stokes parameters is less than standard quantum level corresponding to the coherent light. Recently the PS light formation in periodically inhomogeneous[1] medium have been considered theoretically. However, in the paper [1] only the possibility of PS light generation was studied.

This main aim of this work was to study the PS light formation taking into account the dissipation and thermal noise in the nonlinear medium. We study the behaviour of the Stokes parameters in such cubic - nonlinear periodically modulated medium. All calculations were carried out under the weak damping approximation. To calculate analytically the stochastic characteristics of the Stokes parameters we employed a new approach based on noise delta - correlation properties.

It was shown that the fluctuations of the Stokes parameters contain a coherent part and a noise one which decrease and increase while light propagation through a nonlinear medium, respectively. The maximum fluctuation suppression in the Stokes parameter is reached on the optimal interaction length. The further interaction length growth leads to the noise level increasing and it exceeds the coherent part fluctuations. If the interaction length is considerably long then the Stokes parameters fluctuation level is determined only by the reservoir properties and does not depend on the external radiation.

The results of this contribution is important for estimation of the nonlinear medium length to obtain maximum suppression of the Stokes parameters fluctuation in real situation.

1. A.P. Alodjants, S.M. Arakelian, A.S. Chirkin *J. Exp. Theor. Phys.*, **81**, 34 (1995).

TuS14

Effect of precision on amplitude squeezing in quasi-phase-matched device for harmonic generation

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Quasi-phase-matched (QPM) devices have been attaining great attention for their high effective nonlinearity, through their quantum noise characteristics have not been fully investigated. In this paper, we analyze amplitude squeezing in a QPM device used for the harmonic generation with consideration on fabricational precision.

We consider a polarization-poled $LiNbO_3$ waveguide. Each domain length is assumed to have a normal distribution, whose average $\bar{z}$ and standard deviation are 2.88 μm and $\bar{z}\sigma$, respectively. This average domain length is required for the second-harmonic generation (SHG) from 850nm using d_{33}. The full length of the device is 10mm and the beam cross section is 25μm^2.The initial state of the fundamental wave are supposed to be a coherent state.

Fig.1 and 2 show the evolution of the mean photon flux density of the fundamental wave and that of the harmonic wave, respectively. In the case of σ =1%, the stable SHG is limited due to lack of precision. On the other hand, the growth of the harmonic wave is limited even in the case of σ = 0.1%. This is due to parametric amplification caused by cascaded $\chi^{(2)}$. This result suggests that the amplitude squeezing in QPM devices would have an essential limit that does not exist in birefringent-phase-matched devices. Fig.3 shows the amplitude squeezing of the fundamental wave as a function of the input power. Better squeezing is observed in devices with smaller σ but is limited to a finite value of 75%.

In conclusion, we have analyzed amplitude squeezing in QPM devices used for the harmonic generation, and have predicted that the parametric amplification due to cascaded $\chi^{(2)}$ effect would limit the maximum amount of amplitude squeezing, even if the fabricational precision is greatly improved.

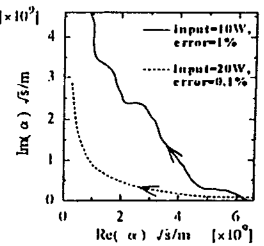

Fig.1 Evolution of mean photon flux density of fundamental wave α .

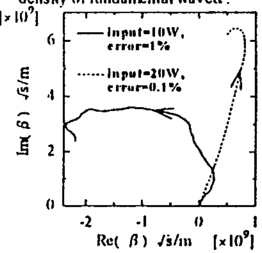

Fig.2 Evolution of mean photon flux density of harmonic wave β .

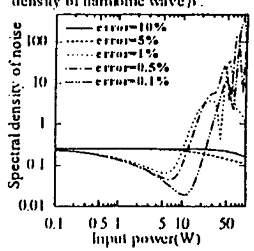

Fig.3 Amplitude squeezing of fundamental output as a function of input power. Shot noise level = 0.25.

TuS15

SQUEEZED LIGHT GENERATION BY ELECTRON BEAMS

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The possibility of generation of non-classical light with considerable squeezing coefficient is of great importance for fundamental and applied physics. However in modern experiment it is very hard to obtain large optical nonlinearities with small losses, therefore the squeezing coefficient achieved so far is moderate. On the other hand the systems with electron beams can provide a very large nonlinearity with small damping of electrons motion.

The simplest model of squeezed states generation in a process of reflection of a powerful electromagnetic wave from a system of free electrons is considered in [1]. In this contribution an interaction of a travelling optical wave with an electron beam is considered. For parametric processes be effective one can use a powerful electromagnetic wave as a pump. The statistical and dynamical characteristics of the electromagnetic field in an output of the system are investigated. The values of possible squeezing coefficient are evaluated. For increasing of the squeezing coefficient one can use a resonator scheme. In this case the requirements to the parameters of the system are reduced.

The modifications of results for large (relativistic) electron velocities are considered. In this case a Doppler frequency shift plays an important role in the dynamics of the system. Parametric interaction is the most efficient in cherenkov case. Optimal bunching of electron beam is obtained. The space period of electron bunching must be a multiple of a half wavelength of an input electromagnetic wave. The squeezing coefficient in this case can be considerable.

The perspectives of practical realization of squeezed states generation schemes based on the considered effects are investigated.

1. V. V. Kulagin, V. A. Cherepenin. JETP Lett., v. 63, N 3, 170 (1996).

TuS16

Optical pumping in Λ-system with squeezed light

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We discuss the optical pumping phenomenon in an ensemble of three level atoms with Λ-configuration by their excitation with squeezed light of parametric luminescence. We have derived the set of quantum kinetic equations describing an atomic evolution driven by the squeezed light of weak intensity. It has been shown, in such a case, that, due to quantum statistical properties of the radiation, redistribution between sublevels of Λ-system is possible even for equal light intensities applied to the optical transitions Λ-system. We discuss in details the relation between optical pumping effect with temporal and spatial spectral properties of squeezing. It has been shown that limited width of the spectrum of squeezing is particularly important for existence of optical pumping effect.

TuS17

SEMICLASSICAL APPROACH TO POLARIZATION EFFECTS IN NONLINEAR OPTICS WITH COHERENT AND SQUEEZED FIELDS

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Generalization of relaxation operator of an atom in broadband squeezed wave is made to account for atomic level degeneracy and polarization state of the squeezed wave. Atomic level degeneracy is due to various orientation of the total angular momentum of atom. The radiation relaxation of an atom under the influence of resonant coherent and squeezed fields is considered for different cases of total angular momentum. The example of resonant atomic transition between levels with value the angular momentum 0 and 1 shows that in contrast to the nondegenerate case, for an arbitrary state of the polarization of the squeezed field, the Zeeman structure will in general increase the minimum possible relaxation constant for the quadrature components of the atomic polarization. It is established that maximum suppression of the relaxation must be expected for a squeezed field consisting of photons with the same circular polarization. It is established that strong degeneracy of resonant levels modifies the exponential character of the radiation relaxation of atomic polarization. For the case of maximum suppression of the relaxation and a resonant transition between levels with the same values of the total angular momentum, the relaxation rate is further decreased, whereas for transitions where the angular momentum changes, relaxation rate increased (compared to the nondegenerate case).

The specific condition on polarization state of the excitation fields explain the current lack of convincing experimental studies of mechanism for suppression of atomic relaxation by a squeezed field.

The equation obtained by the author provide a basis for a semiclassical approach to the polarization properties of (nonlinear) optical phenomena created by polarized coherent and squeezed fields interacting with atomic systems that are degenerate with respect to projection of the total angular momentum.

TuS18

Generation of classical superbunched light in a positive feedback loop

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It is well-known that negative feedback can be used for squeezing of light [1]. The properties of light in the positive feedback loop can be also interesting.

Our feedback consists of an acousto-optic modulator (AOM), a photomultiplier tube (PMT) and a tuned amplifier (TA). This feedback differs from common systems [1] by the absence of a reference beam on the PMT. Therefore, the photocurrent has no high-frequency components. Under such conditions, only the PMT's shot noise is amplified by the TA and excites the ultrasonic wave in the AOM.

The intensity of light in such a system can be written as $I = \frac{C}{1-C} I_0$, where the feedback factor C has casual character. If the mean value of C is not far from the unity, the intensity fluctuations can be infinite. Fig.1 shows the dependence of the second normalised moment $g_2 = \langle I^2 \rangle / \langle I \rangle^2$ of light intensity measured in experiment (dots) and predicted by the theory (curve) taking into account the PMT nonlinearity.

The work was supported by RFBR, grant №96-02-16334a.

[1] D.N.Klyshko, A.V.Masalov; Sov. Uspehi Fiz. Nauk, **165**, 1249 (1995)

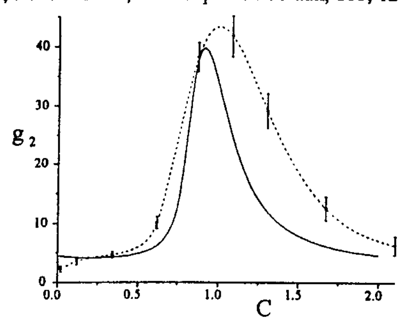

Fig.1. Theoretical (solid curve) and experimental (dots) dependence of the second moment of light intensity on the feedback factor C.

TuS19

AN INVARIANT TREATMENT OF UNPOLARIZED LIGHT AND A NEW INSIGHT INTO POLARIZATION SQUEEZING Of LIGHT FILDS

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New definitions of unpolarized light (UL) are given using invariance properties of the Stokes vector (or P-quasispin) operator moments $< s^m_{i=1,2,3} >$ (or $< P^m_{i=1,2,0} >$) with respect to the $SU(2)_p$ group of gauge polarization transformations of light fields [1]. It is shown that, in fact, the usual (related to standard classical polarization measurements) definition of arbitrary states of UL: $< P_{i=1,2,0} >= 0$ can be given as the invariance of $< P_i >$ (or averages of linear functions $A(\{P_i\})$) with respect to any transformations $S \in SU(2)_p$ [2]: $< SA(\{P_i\})S^+ >=< A(\{P_i\}) >$, and, hence, such light states can be called as the 1-st order (or weakly) UL. Extending this conditions for higher moments $< P_i^m >$ [2,3], one may define higher order (or strongly) UL including both the natural (thermal) UL and P-scalar [1,4] light. At the same time, limiting ourselves in these extensions by transformations $S \in \exp(i\alpha P_0)$, one gets axial (or P_0-invariant) UL including P_0-scalar light generated by helicityless bi-photons [1]. The structure of density operators is determined for different classes of UL, and physical mechanisms of generating these classes are considered. New (in comparison with early results [1,4,5]) measures, schemes and physical interpretations of polarization squeezing of light due to structure peculiarities of the light field phase spaces (as "$SU(2)_p$-bundles") are discussed. It is shown that, in a sense, an absolute polarization squeezing is exactly reached only for states of P-scalar light whereas its other kinds are characterized by non-zero "squeezing levels" determined by degree of polarization and average values of P-quasispin.

REFERENCES:

1.V.P. Karassiov. //J. Phys., v. A26, p.4345 (1993)
2.V.P. Karassiov. // Kr. Soobshch Fiz. FIAN, N5-6, p.13 (1996)
3.J. Lehner, U. Leonardt and H. Paul. // Phys. Rev., v. A53, p. 2727 (1996)
4.V.P. Karassiov. // Phys. Lett., v. A190, p.387 (1994)
5.A.S. Chirkin, A.A. Orlov and D.Yu. Parashchuk. // Quant. Electronics, v. 20, p. 999 (1993)

TuS20

FIELD DISTRIBUTION IN THE CHAIN OF HIGH-QUALITY IDENTICAL RANDOMLY DETUNED NONLINEAR CAVITIES

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The problem of radiation localization in optical linear random medium has satisfactory description by means of mean local intensity value. For nonlinear optical phenomena this description is not correct yet if the localization is strong as in 1-d propagation geometry. For this case the description by random intensity probability distribution is required. In the present work the localization in a dispersive nonlinear system of coupled Fabry-Perot cavities is treated for the first time in this way.

The system under consideration is a chain of high-quality lossless single-mode cavities filled with Kerr medium. The eigenfrequencies of the cavities are distributed randomly around the driving field frequency. For ideal reflecting end of the chain when direct and backward flows of the radiation are locally equal an exact analytical relation is derived for the distribution function of neighboring cavities. For both linear and nonlinear cases ~~the obtained simple~~ analytical expression describes the distribution under the condition that the eigenfrequency dispersion is narrow in comparison with the cavity mode width. By analytical and numerical method we determined large broadening of the distribution function of irradiation in a chain which is longer than the localization length. In case of a nonlinear medium the distribution depends drastically on the sign of detuning of the field frequency from the mean resonance frequency. We determined the domain of the parameters where the distribution function became an ambiguous function of detuning and a multistable state appears.

Although these results were derived for the chain with the ideally reflecting end, they were shown to be applicable for any chain provided its length is larger than the localization length.

TuS21

NONCLASSICAL POLARIZATIONAL PROPERTIES OF THE TWO PHOTON TIME-DELAYED INTERFERENCE IN THREE LEVEL PHASE MEMORY MEDIA

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SUMMARY

Nonclassical properties of time-delayed interference of two photon pulsed fields in three level media with phase memory accompanied by photon echo are theoretically considered. The consideration is based on the dummy quasi-resonant quantum electrodynamical approach for the interaction of a quantum field with a medium. Non-stationary Schrödinger equation for the total wave function is solved using the Hamiltonian $H = H_a + H_f + V$, $H_a = \sum_{j=1}^{N}\sum_{n=1}^{3} E_n^j / n_j >< n_j /$, $H_f = \int d^3k\, \hbar\omega_k a_k^+ a_k$, V – interaction Hamiltonian of the field with atoms for three active transitions: $/1>\leftrightarrow /2>, /1\leftrightarrow /3>, /2>\leftrightarrow /3>$. Initial state of two photon state wave packets is

$$/\psi(-\infty)> = \int_{-\infty}^{\infty} d^3k \int_{-\infty}^{\infty} d^3k' F_a(k', k_{1,2}) F_b(k, k_{1,2}) a_{k'}^+ a_k^+ / o > \otimes / g >,$$

$$F_{a,b}(k, k_{1,2}) = F_{a,b}(k - k_1) + F_{a,b}(k - k_2) e^{ikL},$$

where $/o>, /g>$ – the vacuum state of the field, the ground state of medium. These two photon states are also characterized by different polarization properties of the function $F_{a,b}(k\text{-}k_n)$. The states correspond to two wave packets propagating to medium along two different optical paths and falling on it with delay time τ between each other (τ=L/c).
Finding analytical solution for the $S(\infty,-\infty)$ – scattering matrix of the field $/\psi(\infty)> = S(\infty,-\infty)/\psi(-\infty)>$, we found a quantum average of the operators $<\hat{\hat{E}}(t,r)>$ and $<\hat{\hat{E}}(t,r)\hat{\hat{E}}(t,r)>$ for fields re-radiated by the medium after its excitation. The following result was found. Depending on polarization of initial two photon state, an echo signal can appear or disappear in intensities of re-radiate field, then in the amplitude of field a echo signal will always be radiate. Studying these polarization properties we can separate single photon echo from two photon echo, both single photon state from two photon state. Experimental realization of such effect is discussed, using variants (combined and modified stimulated) of single photon echo signals studied in the works.

S.A.Moiseev Time-delayed interference of a photon and the One-Photon Echo in media with phase memory. Opt. and Spectroscopy. Vol. 83. No.2, 1997, pp.261-274.
S.A.Moiseev Special features of detection of a One-Photon Echo and a Time-Delayed Photon interference in a three-level medium. Opt. and Spectroscopy. Vol. 82. No.6, 1997, pp.943-948.

TuS22

DYNAMICS OF ONE AND TWO-ELECTRON SYSTEMS IN VACUUM DEVICES. MACROSCOPIC ONE-ELECTRON WAVE PACKETS

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It is shown that the dimensions of an electron wave packet in vacuum photodetectors of order of 1 μm. Electron motion in the field of another electron and in the field of a negative charged spherical electrode is investigated. It is shown that interaction between electrons to result in an abrupt squeezing of electron packets and that there is the possibility to unsqueeze electron packets to macroscopic size.

18:30-20:00 **BLUE HALL**
TuT - Nonlinear Optical Phenomena

TuT1

PARAMETRIC SUPERFLUORESCENCE IN NONLINEAR CRYSTAL EXCITED BY BESSEL BEAM

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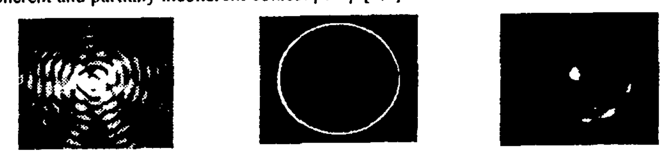
Starting the Durnin's work [1] the properties of Bessel (non-diffracting) light beams are under extensive consideration. Attractive applications of Bessel beams are feasible in nonlinear optics. A common feature of nonlinear optical frequency conversion of Bessel beams is simultaneous noncollinear phase-matching of all plane waves compiling conical pump with excited plane wave propagating in the direction close to cone axis. That was demonstrated in the case of optical parametric oscillator both for coherent and partially incoherent conical pump [2,3].



a b c

In this report we demonstrate for the first time that the output radiation of traveling wave optical parametric generator (TOPG) based on KTP crystal and pumped by the Bessel beam has a transverse profile in accordance with noncollinear phase-matching relations. The spatial profile of the Bessel beam and its angular spectrum are presented in Fig. a, b, accordingly. Two diffraction-limited axial beams and two corresponding conical beams of different frequencies and polarizations were generated (Fig.c). It is shown that directivity of TOPG output radiation is mainly caused by ring-shaped spectrum of the conical pump beam.

References:

1. J.Durnin, J. Opt. Soc. Am. A4 (1987) 651.
2. A.Piskarskas, V.Smilgevicius, and A.Stabinis, Appl.Opt., 36 (1997) 7779.
3. A.Piskarskas, V.Smilgevicius, and A.Stabinis, Optics Commun., 143 (1997) 72.

TuT2

Generation of Continuously - Tunable Radiation Between 0.35 and 1.7 μm Due to SRS-Conversion of Radiation from Ti:Sapphire and $LiF:F_2^-$-Lasers in $Ba(NO_3)_2$ Crystals

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One of the important problems for the laser physics is the creation of all solid-state narrow-bandwidth radiation sources tunable over a wide spectrum range.

To solve this problem, the present paper offers a new method which is based on a complex usage of the fundamental and second harmonic radiation of tunable lasers on Ti:Sapphire and $LiF:F_2^-$crystals and SRS-conversion of these radiations in barium nitrate crystals.

The Model CF-131 Ti:Sapphire laser (SOLAR TII) with a tunability range of 0.69-0.95 μm, a pulse energy of up to 45 mJ (up to 8 mJ at the second harmonic), a spectral linewidth of ~ 0.2 cm^{-1} was used in the experiments. The Model CF-151 laser (SOLAR TII) on a $LiF:F_2^-$ crystal was tunable over the 1.09-1.25 μm range, had a pulse energy of up to 80 mJ (10 mJ at the second harmonic) and a spectrum linewidth of ~ 0.3 cm^{-1}.

By exciting SRS in $Ba(NO_3)_2$ crystals using the second harmonic radiation from the two lasers, four Stokes components tunable from 0.45 to 0.55 μm and from 0.63 to 0.69 μm have been generated. The SRS-conversion efficiency was found to be dependent on the wavelength of the input and output beams and was 10 to 30%. With the fundamental radiation from the said lasers used to excite SRS-converters, three Stokes components, covering the wavelength range 0.9 -1.7 μm with continuously-tunable radiation, have been generated.

The obtained results have been used to produce a narrow-band (≤ 0.3 cm^{-1}) pulsed radiation source, tunable in the 0.35 - 1.7 μm spectrum range.

TuT3

Stimulated Raman scattering of long XeCl laser pulses in silica fibers

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As a rule, the optic fiber delivery systems for high energy in the UV require long duration pulses. However, regardless of the relative low peak power transferred, significant losses could occur due to the stimulated Raman scatering. In this work we study the reshaping of a long duration (70 ns) XeCl laser pulse (308 nm) when propagating through a 70 m silica fiber. The spectrally resolved temporal characteristics of the output pulse show an intensive Raman conversion.

We used step-index OH rich UV silica fibers (CeramOptec, Fiberguide and PolyMicro Technology), with a diameter of 200/220 μm and fiber length of 70 m. The pump pulse and the fiber output pulse spectra we analized simultaneously by means of a prism spectrograph in a single shot regime. For the reliable spectra identification we additionally measured the spontaneous Raman spectra of all three fiber types using 488 nm excitation. Thus we observed that all spectra profiles are identical within a frequency range of 1000 cm^{-1}.

Transmitting a 308 nm pulse through the fiber we recorded both first and second Stokes components centered around 312,5 and 317 nm with thresholds of 200 and 400 MW/cm^2 respectively. The spectrum of the first order Stokes has a two peaks and its shape is close to the corresponding spontaneous Raman spectrum. The shorter wavelength peak, however, is red-shifted in respect to the spontaneous one, which we explain with the two line structure of the pump pulse spectrum. In a contrast, the second Stokes spectrum is smooth without notable structure.

When increasing the intensity of the pump radiation above the threshold values we observed, that both Stokes spectrum shift to red without changing their shapes. The temporal shape of the depleted pump pulse has two asymmetric peaks.

In attempt to understand better the experimental results we numerically simulated the proccesses. The model includes: 1) both stimulated and spontaneous Raman scattering; 2) the linear and nonlinear absorption spectra; 3) multiple order Stokes generation and depletion. When substituting the previosly recorded spontaneous Raman gain spectrum as well as the real specrtal and temporal profile of the pump we found a good agreement between simulation results and experimental data.

TuT4

STIMULATED SCATTERINGS OF LIGHT IN THIN LAYERS OF ACTIVE MATERIALS NEIGHBOUR TO THE SURFACE

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Stimulated scatterings (SS) pulses energetical characteristics in picosecond range have been measured for thin layers of active in SS materials (thickness was compared with focal neck length) in acetone, benzene, cyclohexane, toluene. Measurements have been realized for backward SRS wave. Sharp SRS intensity enhancement has been observed when the focal neck central part was placed at the distance of 5 mm below the nonlinear medium surface. Increasing of the focal neck center deepness inside the medium leads to the decreasing of SRS conversion rate. The length of the maximum conversion of the exciting light into SRS was defined. Efficiency conversion up to 60 % was reached. The results have been compared with the results of object image reconstruction by its Fourier-spectrum [1]. The geometrical and energetical conditions according to the best quality of reconstructed image and simultaneously high efficiency conversion have been found.

In nanosecond range the analogous results have been obtained for stimulated Brillouin scattering (SBS). We observed an increase in the SBS intensity when the exciting laser radiation was focused into the acetone layer neighbour to the material surface. The SBS energy peak was observed when the focal neck center was placed at 3-4 mm below the surface. In order to avoid distortions of the results by the cell windows we directed the laser radiation vertically onto the free surface of the liquid both in the case of pico- and nanosecond pulses. The fundamental importance of the material layer, neighbour to the surface, is shown for the process of the information recording and reconstruction with the help of nonlinear effects.

1. S.Er-rhaimini, J.P.Lecoq, N.P.Xuan, G.Rivoire, N.V.Tcherniega, Optics Communications, v.104, p.132-138, 1993.

TuT5

ON THE POSSIBILITY OF THE CONJUGATION OF CW MULTIFREQUENCY HF-LASER RADIATION USING BAGG SCATTERING IN A HBr-Xe MIXTURE

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It has been known that the existing techniques of phase cojugation (PC) produced as a result of, e.g., degeneration four-wave interaction (DFWI) is stimulated Mandelshtam-Brillouin scattering (SMBS) are not too efficient for PC of multifrequency radiation of a CW HF chemical laser (HF-CL). Specifically, using DFWI for this purpose an individual cell is usually required for each frequency in the HF-CL spectrum, and the optical configuration becomes quite cumbersome and not to attractive. Although problems of this kind do not arise in the case of PC produced as a result of SMBS, the existence of a high-intensity threshold of SMBS also preclude the attainment of a sufficiently high cojugation efficiency for the radiation of a CW HF-CL. An approach to PC of multifrequency radiation of a CW HF-CL using Bragg scattering in a resonantly absorbing medium is considered. The choice of working components of this medium, HBr and Xe, is analyzed at length. Numerical calculations are performed employing a mathematical model presented in this report; the reflectivity is plotted as a function of the component concentration ratio, the intensities a PC cell, and the angle of their convergence. The problem of cooling the medium by mixture circulation. The calculations show that the approach suggested is a candidate for implementing the PC of a high-power multifrequency HF-CL.

TuT6

EFFICIENT RAMAN SHIFTING OF PICOSECOND ND:YAG RADIATION BY KGW CRYSTAL.

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The stimulated Raman scattering (SRS) is a rather effective way to obtain the frequency shifting to various spectral regions. Solid-state materials have obvious advantages for SRS as it allows high concentration of active Raman centers and thus essentially smaller dimensions [1].

In the experiments the KGW crystal 4x4x40 mm was pumped by first or second harmonic of mode-locked Nd:YAG laser. The laser emitted the train of approximately 5 pulses with 30 picosecond duration each.

The forward scattered radiation contained at least three Stokes components (λ_{1st}=1.18 μm, λ_{2st}=1.32 μm , λ_{3st}=1.5 μm) and one anti-Stokes component (λ_{1ast}=0.97 μm). The obtained threshold intensities, defined as the point where 1% of the pump intensity has been converted to the Stokes intensity [2] and calculated threshold gains G_{ss}^{th} are presented in Table 1. The value of the transient threshold gain G_{ss}^{th} *averaged using different pump cases was calculated to be about 67±3 being* approximately the factor of 2.7 larger than the steady-state threshold gain. It should be noted that the corresponding value of transient SRS threshold gain for $Ba(NO_3)_2$ crystal was measured to be G_{ss}^{th}=260±30 [2] which was about 3 times higher than that for KGW crystal.

The efficient SRS in KGW Raman crystal was observed under excitation with picosecond green and IR laser pumping. The shorter vibrational dephasing time for KGW crystal result in lower thresholds compared to $Ba(NO_3)_2$ crystal which is opposite to nanosecond pulse pump. These results show the possibility to use the KGW crystal for Raman shifting of picosecond pulse neodymium lasers to the 1.5 μm region with efficiency up to 0.5% using the third Stokes generation or can be applied to obtain 1.5 μm as the first Stokes component if the 1.32 μm lasing transition of neodymium is used.

Table 1. Measured threshold pump intensities I_p and calculated on their basis threshold SRS gain G_{th} for KGW Raman crystal under IR and green pump.

Pump wavelength λ_p, mm	First Stokes wavelength λ_1, mm	Pump beam diameter d, mm	Threshold pump intensity I_p, GW/cm^2	Threshold SRS gain G_{th},
0.532	0.578	0.15	0.71	68
1.064	1.18	0.15	2.7	65
1.064	1.18	0.11	2.9	70

References
1. Godehard Hilfer, Curtis R. Menyuk, Stimulated Raman scattering in the transient limit, Opt. Soc. Am. B, Vol. 7, No 5, 1990.
2. P.G. Zverev, J.T. Murray, R.C. Powell, R. J. Reeves, T.T. Basiev, Stimulated Raman scattering of picosecond pulses in barium nitrate crystals, Optics Comm., Vol. 97, No 1,2.

TuT7

Spatial information transfer from a laser to a stimulated Raman scattered beam

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We study here the possibility of transfering a 2D transverse pattern from the exciting laser beam to the Stimulated Raman scattering (SRS). Previously such an image transfer has been produced with the help of the phenomenon of phase conjugation in the backward scatterings[1]. Here, we use forward as well as backward SRS produced in dense materials displaying high Raman gains.

The main problem in the image transfer concerns the phase. SRS being built from the spontaneous noise, there is no initial phase link between the laser and SRS waves[2]. Then, the use of an important laser diffractive coupling, i.e the laser interferences during the propagation in the Raman cell, seems necessary to avoid the phase instability and allows to consider in the same time the transfer of the laser spatial phase and of the laser amplitude pattern to the Raman field.

A Fourier optical set up is particularly convenient: focusing provides a strong diffraction of the laser beam. In experiments using the Fourier device, two different cases are considered: with a weaker focusing, the Raman image differs from the laser one[3], but with a strong focusing, we obtain interesting degrees of reproduction of the laser images on the forward and backward Raman beams.

However, even in the last case, different results may be separated: we have either a high efficiency or a high quality of reconstruction. In fact, we see that the transfer of the spatial information from the laser wavelength to the SRS one may serve either for the laser beam shaping or for the imaging processes.

References:
1- B.Y. Zeldovich, N.F. Pilipetski and V.V. Shkunov, Principles of phase conjugation, Springer Series in Optical Sciences, Vol. 42, Springer, Berlin, 1985.
2- F. Vaudelle, J. Gazengel, G. Rivoire, "Experimental studies of the spatial coherence of forward Stimulated Raman scattering in dense materials", Optics Communications, Vol. 134, pp. 559-568, 1997.
3- F. Vaudelle, J. Gazengel, G. Rivoire, "Image transfer from an exciting laser beam to a stimulated Raman beam: the role of the scattered wave phase in a Fourier optical setup", JOSA B, Vol. 14, pp. 2260-2267, 1997.

TuT8

FORMATION OF ULTRABROAD SPECTRUM BY COMBINATION OF FEMTOSECOND SRS AND SPECTRAL CONTINUUM GENERATION.

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We carry out experimental study of the new method of spectral broadening due to SRS and spectral supercontinuum generation (SCG) in H_2, HD, D_2 and CH_4 gases pumped by second harmonics of Ti:S regenerative-amplified laser system (Clark-MXR SPA- 1 model, $\lambda = 390$ nm, $\tau = 300$ fs, W = 0.2 mJ, f = 1 kHz).

The highest broadening of 1250 cm^{-1} (FWHM) is achieved in SRS Raylegh component (around 390 nm) in H_2 (45 atm) with circular polarization pump of 0.1 mJ focusing by 25 cm lens. The shortest pulse attainable by compression of this continuum is obtained by Fourier transformation (FT) of the spectrum, assuming a constant spectral phase. This may yield a pulse duration of ~ 12 fs. The first Stokes component (around 465 nm) broadens up to 866 cm^{-1} (16 fs FT) with linear polarization pumping and focusing by 100 cm lens. In CH_4(30 atm) the first Stokes (around 440 nm) broadens up to 714 cm^{-1} (20 fs FT). In HD (26 atm) and D_2 (60 atm) the Raylegh and first Stokes broaden up to 500 cm^{-1} (29 fs FT). In experiments we also observe the increasing of spectral broadening on higher Stokes and anti-Stokes components.

For experimental compression of these ultrabroad spectra we need to know amplitude-phase time characteristics of all Fourie spectral components. We carry out theoretical study of nonlinear wave equations for light fields (not for slowly varied amplitude) taking into account electron and electron-vibrational nonlinearities. Based on analyses of these equations solutions we show the possibility of highly efficient compression the SCG.

TuT9

Spectral Characteristics Backward Stimulated Raman Scattering Initiated by the Quantum Noise.

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The results of detail calculations of the backward stimulated Raman scattering (BSRS) formation from the quantum noise [1] are presented. The calculations have been carried out for specific experimental conditions [2]: laser pulses from a frequency-doubled Nd:YaG with a pulse duration of 9 ns were focused into the 45 cm H_2- cell filled at 20 atm. The amplitudes and phases of both backward and forward waves have been simulated by the Monte-Carlo technique, applied to a system of equations for the amplitudes of coupled laser, forward and backward waves as well as for two polarization amplitudes with additional stochastic sources of quantum fluctuations to the opposite directions. Note that the sources were not correlated in the calculations, and their intensities have been chosen in accordance with the experiment [2] geometry. The dynamic of the BSRS spectrum was calculated on the basis of the fast Fourie transform and also on a method adjusted to spectral measurements using a Fabry-Perot interferometer followed by a streak camera.

The simulations show well pronounced fluctuations of the pulse energy, while the thin structure of the BSRS spectrum is only slightly dependent on initial quantum noise. The structure appeared for a highly nonlinear regime of the scattering when the second threshold is achieved and the pump is almost depleted. A small fluctuations of the temporal position the leading edge of a sharp forward Stokes pulse as well as the position of a first spike in modulated structure of the BSRS pulse have been observed. The width of the spectral mode of BSRS and their time displacement are in a good coincidence with the experimental observations [2].

1. Apanasevich P.A., Zaporozhchenko R.G., Zaporozhchenko V.A., Kilin S.Ya., and Orlovich V.A. , Laser Phys. v.6, N6, (1996), 1198.
2. Bespalov V.G., and Staselko D.I., Optika i Spectroskopiya, v.82 N5, (1997),734.

TuT10

SBS LASING CAUSED BY DOUBLE RAYLEIGH SCATTERING IN FIBERS.

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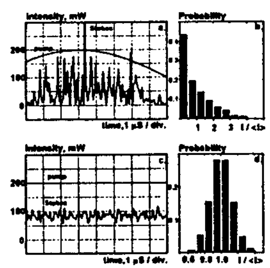
We consider SBS process in optical fiber at the presence of additional feedback caused by double Rayleigh scattering of SBS-amplified Stokes waves. In the experiment the radiation of single-frequency Nd:YAG laser (1.06μm, linewidth ~50 kHz) is launched into 300 m silica singlemode optical fiber (~17 dB/km losses). From the first Rayleigh feedback is suppressed by means of slight pump modulation (Fig.,a). The intensity of the Stokes wave exhibits 100% temporal fluctuations. The normalized standard deviation of the Stokes intensity is unity. Intensity correlation function is Caussian curve with correlation time of ~50nS. The Stokes spectrum linewidth is about 10 MHz. Histogram of the statistical distribution of the Stokes intensity fluctuations (Fig.,b) points to nearly Gaussian statistic of the Stokes field fluctuations.



Qualitatively different oscilloscope traces (Fig.,c) are obtained in the experiment with good pump intensity stability. The depth of the Stokes signal temporal fluctuations is less then 30%. The correlation function for Stokes intensity corresponds Gaussian shape with the same correlation time, but the normalized standard deviation of the Stokes intensity is about 0.1. The Stokes linewidth measured by 2km self-heterodyne interferometer is smaller then 0.1 MHz. The histogram of the statistical distribution of Stokes intensity fluctuations (Fig.,d) shows that Stokes intensity (but not field) fluctuations are in Gaussian statistics. That points to SBS lasing process in the fiber.

The results of the numeric simulation of the cooperative RS-SBS process in the optical fiber are in excellent agreement with the experimental results.

TuT11

COMPARISON BETWEEN DIFFERENT TYPE FEEDBACK SBS-MIRRORS USED IN SOLID-STATE LASER.

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SBS-mirror with phase conjugation located outside the main cavity considerably affects the dynamics of generation and output characteristics of the solid-state laser. The comparative investigation of the loop [1] and the ring [2] SBS-mirrors influence on the solid-state laser action is presented in this paper.

It was found that the peak power increase approximately identicaly with both types of feedback and was equal 5-6 times in relation to usual SBS-mirror excited for one pass of a nonlinear medium. The output power growth was not accompanied by the beam quality worsening in compare with single mode initial radiation in the both cases and the laser output beam quality was nearly difractional. The feature of the ring SBS-mirror, that differ it from the loop configuration, was a beam-splitter which was necessary for the ring feedback connection. At the same time it was an isolator between the laser and the SBS-mirror and it was necessary to optimize its reflection. The dependence of the output laser power P_L on looses in optical feedback scheme was different for these configurations: P_L decreased very slowly for the ring SBS-mirror, but loose's influence was significante in the case of the loop configuration. The most important distinction between two SBS-mirrors was a presence of the laser pulse amplitude fluctuations in the ring scheme. These fluctuations result in the average output power decrease in compare with ring configuration. The observed regularities were explained as a result of the difference of the SBS-enhance physical mechanisms in these schemes.

References:

1. Odintsov V.I., Rogacheva L.F. // Sov. Phys. JETP Lett. 36. 344 (1982).
2. VokhnikO.M., Mikhailov V.A., Spazhakin V.A., Terentyeva I.V., Shcherbakov I.A. // Optica i spectroscpiya. 78. 338 (1995).

TuT12

FOUR-WAVE MIXING DYNAMIC GRATING STRUCTURE INVESTIGATION.

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The paper is devoted to the theoretical consideration of the structure of the dynamic grating established in a crystal with a non-local response during photorefractive four-wave mixing (FWM). Holographic grating structures in the case of two-wave mixing dynamics for the first time were considered in [1] as a grating envelope propagation. In the case of transmission FWM the steady state holographic grating has the amplitude distribution of the motionless "soliton". With the model of exact non-local response, every fixed input ratio of waves' intensities and phases determines the stable grating "soliton". So smooth variations of input parameters involve smooth exchanges of the steady state grating structure; and different grating structures correspond to any variations of input waves conditions.

In the steady state case, there is the simple fundamental solution describing the double phase-conjugation mirror (DPCM). FWM theoretical description allows to use the DPCM solution in the case of the usual FWM by the submission of FWM boundary conditions on such imaginary boundaries, where the intensity of one of the interacting waves equals zero. By this method FWM steady state solutions are obtained for both arbitrary nonlinear response and exact photorefractive non-local response. In latter case, noted boundaries can really exist within PRC, if coupling constant PRC is great ($\gamma l>2$). Then these boundaries are sections of edge dislocations of light interference field. As well areas of "reverse" energy transfer between two waves, propagating in one directions, are established within PRC. That is the energy transfer direction of two interacting waves is opposite to the direction of PRC pole axis.

Dynamics of grating recording is described by modified sin-Gorlon equation [1,2]. From dynamic analysis it follows, that for certain input beam ratios bistable solutions may exist in strong response PRC, which differ by steady state grating structures. This different grating will be recorded in PRC, if in the beginning some initial transmission grating is recorded, and then the phase difference of one input wave is changing by π.

References.

1. Jeganathan, M. C. Bashaw, and L. Hesseling, "Evolution and propagation of grating envelopes during erasure in bulk photorefractive media", J. Opt. Soc. Am. /B 12, No. 7, 1370-1383 (1995).
2. Bugaichuk, A. G. Kutana, A. I. Khizhnyak, "Dynamics of transmission grating recording during FWM in nonlocal responded photorefractive medium", Ukrainian Journal of Physics, vol.42, No.6 (1997).

TuT13

Role of dressed states in resonant four-wave mixing with large Doppler broadening

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Experiments on resonant four-wave mixing demonstrated high-efficiency CW down-conversion of frequency in gas [1]. Meanwhile, the high amplitudes of input waves make the perturbation theory invalid to understand the behavior of output power measured as a function of input powers and frequencies.

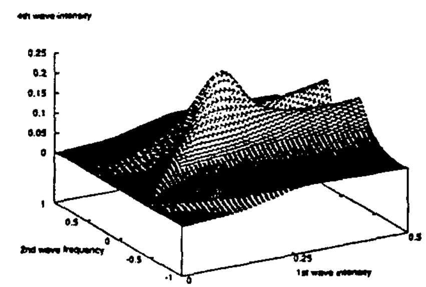
Here we calculate the nonlinear susceptibility of optically thin medium for Raman scheme $\omega_4 = \omega_1 - \omega_2 + \omega_3$, where fields 1, 3 are strong and 2, 4 are weak. In symmetric case $\vec{k}_2 = \vec{k}_4$ the integral over velocity can be calculated analytically for Doppler limit [2]. The compact explicit formula yields the intensity and frequency dependence. The peak of mixing coefficient as a function of intensity is found around equal Rabi frequencies of fields 1 and 3 (peak in Fig.1). The number of peaks in spectrum depends on parameters. Fig. 1 illustrates how the number changes with the pump intensity. The effect is based on resonance between two closed cycles via sublevels of dressed states.

Explicit formula allows interpreting the measurements and predicting the optimal set of parameters for high conversion effeciency in gas with large Doppler broadening.

References

[1] S. Babin, U. Hinze, E. Tiemann, B. Wellegehausen, *Opt. Lett.* **21** (1996) 1186.

[2] S. Babin, E. Podivilov, D. Shapiro, *Pis'ma v Zh. Eksp. Teor. Fiz.* **66** (1997) 777.



TuT14

Magnetization-Induced Second Harmonic Generation in Ultrathin Au/Co/Au and Pt/Co/Pt Films

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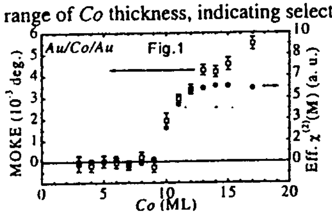
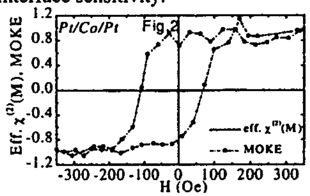
In centrosymmetric metallic layered structures the second harmonic generation (SHG) is only allowed in the electric-dipole approximation for surfaces and interfaces where the space-inversion is broken. For the metallic layered structure possessing magnetization **M**, the nonlinear polarization **P**(2ω) can be expressed as

$$P(2\omega) = \varepsilon_0\chi^{(2)}E(\omega)E(\omega) \pm \varepsilon_0\chi^{(2)}(\pm M)E(\omega)E(\omega)$$

We studied ultrathin *Au/Co/Au* and *Pt/Co/Pt* metallic trilayers with *Co* thicknesses ranging from 3 to 17 atomic monolayers (ML) by SHG and longitudinal magneto-optical Kerr effect (MOKE) using a femtosecond mode-locked *Ti*:sapphire laser. SHG (black dots) and MOKE (white squares) in *Au/Co/Au* film are shown as a function of *Co* thickness in Fig. 1. SHG was measured in longitudinal geometry, using a *p*-polarized incident beam. From 3 ML to 9 ML the sample has an uniaxial magnetic anisotropy with the easy axis perpendicular to the film surface. No signal could be detected for these thicknesses. For thicknesses from 12 ML to 17 ML, the *Co* layer has an in-plane magnetization. MOKE varies linearly with *Co* thickness, as it is bulk sensitive. The nonlinear susceptibility $\chi^{(2)}$ corrected for *Co* absorption is saturated in this range of *Co* thickness, indicating selective interface sensitivity.





TuT15

SECOND HARMONIC GENERATION IN THIN QUADRATIC NONLINEAR FILMS OF TIGHTLY FOCUSED BEAMS.

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Laser fluence durability of condensed materials under illumination by femtosecond pulses is much larger than under pulses of nanosecond duration. Thus one may achieve nonlinear (NL) length of second harmonic generation (SHG) in highly NL media at lengths less than coherent length inherent to corresponding material. Common value of coherent length when all spectral lines are far from absorption bands of NL medium are in the range 5-10 μm. Thus the necessity of phase-matching fails and by tightly focusing the efficient laser frequency conversion may be achieved for light pulses of moderate peak intensity in thin films of NL material.

Such method of SHG may be used either for pulse frequency conversion in technique of short pulse duration measurement (autocorrelators, FROG) or in other applications connected with laser frequency conversion.

Certainly, the largest known second-order nonlinearity is about 300 pm/V (MNA - organic crystal and PhTCV doped polymeric film [1] if concentration of active molecules is close to 1 M and polarisation degree is close to, 100%), so to convert 10% of light energy into SH in 5 μm length of such medium (tightly focusing leads to shorting of the interaction length) it is necessary to provide fundamental power flux density 50-100 GW/cm^2. Such power density will not destroy film material only if pulse duration will be in femtosecond rage. This power flux density may be obtained by focusing the radiation of femtosecond Ti:sapphire laser radiation with the help of microscopic objective with numeric aperture 0.65.

In this report we present the results of numerical and experimental investigations of the regime of SHG of tightly focused laser beam in thin NL films of poled PhTCV/PMMA.

References

1. D.R. Yankelevich, P. Pete, A. Knoesen, G. Taft, M.M. Murnane, H.C.Kapteyn and R.J. Twieg, Opt. Lett. **21**, 1487-1489 (1996).

TuT16

QUASI-PHASE MATCHED SECOND HARMONIC GENERATION IN A CZOCHRALSKI-GROWN PERIODICALLY POLED $LiNbO_3$ CRYSTALS

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Bulk periodically poled $LiNbO_3$ crystal is a promising material for nonlinear optical devices using quasi-phase matching. In particular, frequency doubling of near-infrared radiation into the blue spectra range and optical parametric oscillation are of importance. The spatial modulation of the nonlinear susceptibility is realized in lithium niobate by formation of periodically reversed domain pattern. In this study the periodic domain structure was formed in $LiNbO_3$:Nd:Mg crystals by means of the modulation of impurity incorporation during the process of crystal growth.

The crystals were grown along the direction of the normal to the $(01\bar{1}2)$ face. The face at the growth front gave rise to a system of laminar domains with flat boundaries, so that the normal to the boundaries located in the YZ plane was oriented at 57° to the Z axis. Quasi-phase matched (QPM) second harmonic generation (SHG) in a $LiNbO_3$:Nd:Mg crystal was studied with a pulsed dye laser. In a collinear geometry where the fundamental wavevector is perpendicular to the domain walls, phase-matching between the fundamental and second harmonic was obtained at room temperature by tuning the fundamental wavelength. The first-order QPM wavelength was 956 nm, which agrees well with the average domain length of 2.4 μm obtained from the light diffraction measurement. The effect of irregular domain size was numerically calculated to explain the asymmetry in wavelength tuning curve for SHG. The effective interaction length of about 0.7 mm was estimated from the width of wavelength tuning curve. We also measured the second harmonic pulse energy at the QPM wavelength versus input fundamental energy. Due to the largest nonlinear optical coefficient d_{33} dominantly used in this collinear configuration, the conversion efficiency of 23.3% was achieved just below the optical damage threshold at fundamental beam intensity of 160 MW/cm^2.

TuT17

SECOND HARMONIC GENERATION AND DIFFRACTION OF FEMTOSECOND LASER PULSES IN CHIRAL Sm–C LIQUID CRYSTALS

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The liquid crystal (LC) in Sm–C* phase has a helical stack of layers of tilted molecules. This kind of LC objects is chiral materials, where several interesting phenomena could be studied. The first one concerned with the optical diffraction of the light propagation perpendicular to the twist axis. In this case the structure acts as a one-dimensional phase grating resulting the diffraction of the light. Such studies are already known with the use of CW laser sources [1], but the special interest is in the study of the diffraction in LC sample together with the nonlinear interactions at the same time. In this case the SHG enhancement may take place under the origin of additional phase matching conditions [2].

In this work we present new experimental results of the optical diffraction observation for the light propagation perpendicular to the twist axis in the chiral Sm–C LC and SHG under the conditions of diffraction in the structure.

We study the polarization features of the diffracted field in the intermediate case of Raman-Nath and Bragg diffraction regimes [3]. The enhancement of the SH signal generated in the medium under the diffraction conditions has been observed.

References.

[1]. K.A.Saresh, Yuvaraj Sah, P.B.Sunil Kumar, and G.S.Ranganath, Phys. Rev. Lett, 72, 2863 (1994)

[2]. M.Scalora, M.J.Bloemer, A.S.Manka, J.P.Dowling, C.M.Bowden, R.Viswanathan, and J.W.Haus, Phys. Rev. A, 56, 3166 (1997)

[3]. M.G.Moharam, T.K.Gaylord, and R.Magnusson, Opt. Commun., 32, 19 (1980)

TuT18

NEW CONFIGURATION OF OPTICAL WAVEGUIDE MODE ULTRA HIGH FREQUENCY SHIFTER

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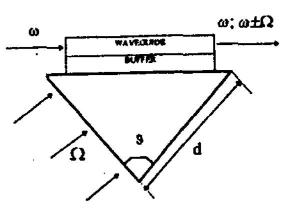
The losses in electrodes extremely decrease efficiency electrooptical frequency shifter at frequencies above 100 GHz. A new non-electrode configuration, where the mode of electrooptical waveguide (EOW) interacts with the surface millimeter (MM) wave is suggested. Surface wave is created on the basement of a MM waveband monolithic total internal reflection prismal resonator [1]; it propagation constant can be varied by choosing of materials and angle θ of prismal resonator vertex as well. The high-Q cavity (unloaded Q-factor about 2000) essentially increase the field MM wave within EOW and will promote to the development of phasematched 3-wave interaction. Frequency shifter at 150÷200 GHz for z-cut, y- propagating planar $LiNbO_3$ waveguide, formed on basement of sapphire prismal resonator has been designed. In this case frequency shifting is accompanied by simultaneous optical mode conversion TE→TM or TM→TE. Due to the reversal of sign of optical waveguide birefringence between these to cases the device operates either as frequency up- or downshifter [2]. There are optimum thick of buffer layer and prism dimension *d* for given Ω and reflectivities of both faces of *prism*, which gives the maximum conversion efficiency η. The value η is about 27% for input MM power 10W. Suggested configuration is expected to find applications for optical parametric oscillator in Cherenkov idler configuration [3] as well.



1. K.N.Kocharian, E.L.Sarkissian, Yu.H.Avetisyan. Int.J. Infrared & MM waves, v.17, pp.1607-1609, 1996.
2. R.Stolte, R.Ulrich. CLEO/Europe'96, Hamburg, Germany, Tech. digest, p.297.
3. V.Rastogi et al. J. Opt. Soc. Am. B, v.14, pp.3191-3195, 1997.

TuT19

REDUCTION OF SWITCHING INTENSITY AS A RESULT OF USING CHIRPED QPM IN DEVICES BASED ON SECOND ORDER CASCADING

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The combination of two novel techniques second order cascading and quasi phase matching (QPM) can yield to a solutions for construction small, low power operated, all-optical switching devices. Important parameters in this devices are the switching intensities $I_{\pi/2}$ or I_π necessary for obtaining nonlinear phase shift (NPS) with amount of $\pi/2$ or π, correspondingly. Here we show that one way to reduce the parameters $I_{\pi/2}$ and I_π is to use aperiodic quasi-phase matched structure. We investigated the NPS obtained by the fundamental beam involved in the process of second harmonic generation in second order material for which the phase mismatch satisfy

$$\Delta k(z) = k_{2\omega} - 2k_\omega - K_{grat}(z) = \Delta k_0 - pz\,,$$

where $\Delta k_i = 2\pi n_i/\lambda_i$ $(i = \omega, 2\omega)$, p is a coefficient and $K_{grat}(z) = 2\pi/\lambda_{grat}(z)$ with λ_{grat} being the grating period. We show here that linear change of $K_{grat}(z) = K_0 - pz$ leads to significant reduction of the switching intensity in the comparison to the devices that use constant Δk_0.

Corresponding amplitude equations for SHG with assumption that Δk vary with z have been solved numerically. On Fig. 1 are shown the NPS (solid line) accumulated by the fundamental beam at the first point of the full intensity reconstruction and input intensity (dashed line) corresponding to this point for both positive and negative values of Δk_0. From this figure were found the optimal value for Δk_0 for obtaining NPS equal to $\pi/2$ and $-\pi/2$. The type of the grating, that is different for $\Delta k_0 > 0$ and $\Delta k_0 < 0$ is shown as inset for both cases.

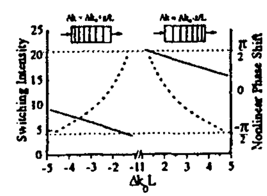

Figure 1

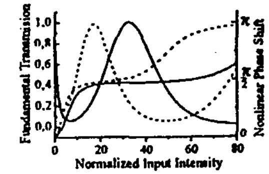

Figure 2

On Fig. 2 are presented the NPS and the transmitted fundamental intensity versus input intensity for both cases: constant Δk with $\Delta kL = 0.3$ (solid line) and linear change of Δk with $\Delta k_0 L = 1.55$ (dashed line). It is seen 50 % reduction of $I_{\pi/2}$ in case of using chirped QPM structure. Further optimization of $\Delta k(z)$ dependance can lead to even stronger reduction of the switching intensities.

TuT20

5 waves mixing in the planar waveguide

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Study of nonlinear stage of evolution of amplifying fields in different schemes of parametric wave mixing has obvious practical interest [1]. To overcome corresponding analytical troubles we developed exact and approximate approaches [2-4]. We derive model describing mixing of three fields F_i (i=1-3) in a thin planar nonlinear waveguide. Two additional fields $P_{1,2}$ are the pump fields propagating in direction perpendicular to that of above mentioned fields. Specific physical conditions and geometry of interaction lead to a novel evolution model derived here. We find conditions then the model is integrable. The initial conditions correspond to arbitrary constant amplitudes of evolving fields. For amplifying fields are initially small and amplitudes and phase factors are slow functions of space and time variables novel type of similarity solution describing amplification of fields F_i is found. This solution can be interpreted as an infinite train of solitons with moving parameters. It is found that for length of the medium exceeding a few characteristic length of nonlinear transformation evolution the dependence on similarity variable gives rise the main contribution to this solution. Such behavior dominates even if initial conditions leads to generation of conventional solitons. Relative technique for finding the solitons in considered model is developed. We show that "conventional" solitons are stable and corresponds to bright or dark solitons on a background which is fixed by "pumping" fields $P_{1,2}$.

We show that results can be directly used for analysis of nonlinear effects in a model of parametric 4 waves mixing in a two-level system if resonance conditions correspond to two photon interaction of fields F_3 and constant field F_4 , and degenerate two-photon interaction of the pumping fields such that $P_1 \equiv P_2$. Then above model can be directly used in this case as well if change of the level population and nonlinear Stark effects are taken into account. Results are compared to known experimental ones.

1. J. F. Reintjes, *Nonlinear optical parametric processes in liquids and gases* (Academic Press, NY 1984).
2. A. A. Zabolotskii, ZhETF, 112, 2237 (1997).
3. A. A. Zabolotskii, Phys. Rev. E 56, 4813 (1997).
4. A. A. Zabolotskii, Phys. Rev. A **58** (1998) (in print).

TuT21

SUM-FREQUENCY GENERATION IN AN ISOTROPIC GYROTROPIC MEDIUM BY COLLINEAR PUMP BEAMS

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We propose a new scheme of sum-frequency generation (SFG) in a noncentrosymmetric liquid with the use of two coaxial Gaussian beams. This effect is only possible if focusing of the beams is correctly taken into account, while, based on the plane-wave approximation, one could expect the sum-frequency signal to be only generated in the noncollinear wave-interaction geometry, just as in the first experiment on SFG in a chiral arabinose solution [1]. The focusing gives rise to a longitudinal field component in each beam, thus inducing the vortex constituent of the sum-frequency polarization of the medium. This vortex polarization is of the first order of smallness in the divergence angles of the pump beams, but still generates a non-vanishing free electromagnetic wave on the sum frequency. The method of solving the SFG problem is much similar to that used in our recent paper [2] which is devoted to studying second-harmonic generation in an isotropic medium by a focused laser beam.

In our present work expressions are obtained for the electric field and for the power of the sum-frequency wave. The case of tight focusing of the pump beams to the center of a long medium is studied in detail. We considered the transverse distribution of the signal-beam intensity as well as the dependencies of its power on the wave-vector mismatch, on the ratio of the half-widths of the pump beams in their waist plane, and on the polarization states of the beams. A quasi-synchronism is predicted which can dramatically increase the efficiency of the three-wave-mixing process under study, thus making this relatively weak effect a good candidate for experimental realization.

1. P. M. Rentzepis, J. Giordmaine, K. W. Wecht, Phys. Rev. Lett. **16**, 792 (1966).
2. S. N. Volkov, N. I. Koroteev, V. A. Makarov, Zh. Eksp. Teor. Fiz. **113**, issue 5 (1998) [English translation: JETP **86**, no. 5 (1998)] *(to be published).*

TuT22

SHADOW CONICAL REFRACTION WHEN THE OPTICAL HARMONICS ARE GENERATED

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During the distribution of radiation alone the optical axle of biaxiality crystal, behind crystal we can see a cones of optical radiation. Phenomenon of conical refraction relates to radiation as well on the frequency of the optical harmonic. Dynamics of organization cones on the frequency of the second harmonic in the crystal $LiCOOH{\cdot}H_2O$ is shown in the work.

We can see below a phenomenon of the conical refraction on the frequency of the second optical harmonics when the part of rays is missing in the bunch of rays. For example this situation could be made when a small around diaphragm is brought in to a collimated bunch. In this case a shadow picture of cone's refraction is seen on the background of radiation.

When we used a divergent laser's radiation then after a non-linear optical crystals we can see a shadow ring structure on the background of radiation of the second harmonics on the screen. In this case the radiation which is transformed in crystal is gathering by objective on the screen which is located after a crystal.

The experimental results was proved by theoretical calculations.

TuT23

EFFICIENT PICOSECOND MID-IR OPO BASED ON $AgGaS_2$ CRYSTALS.

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Powerful sources of picosecond light pulses tunable in the middle and far infrared range are in need for different spectroscopic applications. A well-known way to produce such pulses is to convert a fixed-frequency radiation of Nd:YAG laser into the tunable one via parametric process in a nonlinear crystal. The abilities of this technique are strongly determined by the properties of the accessible crystals, i.e. their transparency range and nonlinear susceptibility, as well as the damage threshold, the optical quality and the size.

Silver thiogallate ($AgGaS_2$) is potentially suitable for parametric conversion of λ=1.064 µm radiation into the wavelengths up to λ~10 µm. The big highly homogeneous crystals of $AgGaS_2$ recently grown in Kuban State University were used to create optical parametric oscillator (OPO) pumped by a single picosecond pulse of Nd:YAG laser. The available crystals were tested in two different noncollinear configurations of OPO. The first one is a single-pass two-crystal arrangement. The second one is the original single-crystal two-pass configuration [1]. Both arrangements provided the higher conversion efficiency in the range 5.3÷7.4 µm than previously reported by Elsaesser et al. [2]. The two-pass arrangement makes possible to obtain the same conversion efficiency as a traditional single-pass two-crystal using only one crystal. It also provides a straightforward way to narrow the spectrum of output radiation. The single-crystal two-pass OPO enabled to reach the quantum conversion efficiency of 7.5% at λ=5.39 µm (30 ps, 23 uJ pump at 1.064 µm).

REFERENCES

1.BadikovV.V., Blinov P.S., Kosterev A.A., Letokhov V.S., Malinovsky A.L., Ryabov E.A., *Quantum Electronics* 27 (6), 523 (1997)

2. Elsaesser T., Seilmeier A., Kaiser W., Koidl P., Brandt G. *Appl.Phys.Lett.*, 44, 383 (1984)

TuT24

Control of Third-Harmonic Generation in Hollow Optical Fibers due to Cross-Phase Modulation

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Nonlinear-optical interactions of high-power short laser pulses in the waveguiding regime in gases and plasmas have been recently demonstrated to offer much promise for pulse compression [1], optical frequency conversion [2], and supercontinuum generation [3]. A hollow-fiber technique, introduced by the authors of [1], allowed compression of 20-fs pulses with an energy up to 70 μJ to a duration of 5 fs due to the self-phase modulation (SPM) of short pulses with subsequent chirp compensation. Since the fundamental pulse propagating in a hollow optical fiber efficiently interacts with its third harmonic [2] and, at the same time, displays noticeable self-phase modulation, it would be reasonable to assume that the phase of the third harmonic can also experience modulation due to cross-phase modulation (XPM) [4].

In this paper, we demonstrate that effects of cross-phase modulation (XPM) may have a considerable influence on the process of optical-harmonic generation in gas-filled hollow fibers, allowing compression of the third harmonic and permitting a control of its intensity-dependent phase shift. Based on the analysis of coupled equations governing the propagation of the fundamental pulse and the third harmonic in a medium with instantaneous Kerr nonlinearity with allowance for the dispersion of waveguide modes within the framework of the first-order dispersion theory, we will derive expressions for the field of the fundamental pulse and the third harmonic and demonstrate that XPM makes it possible to implement controllable broadening of the spectrum of the third harmonic emerging from a hollow optical fiber, permitting subsequent pulse compression (Fig. 1). It will be also shown that an additional shortening of the third-harmonic pulse can be expected in the case when intensity-independent phase mismatch of the third harmonic is compensated for by SPM- and XPM-induced phase shift near the maximum of the fundamental pulse.

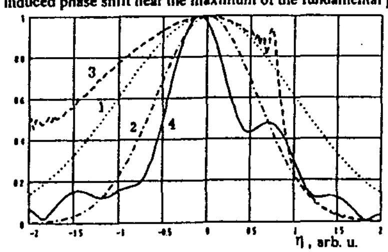

Fig. 1. XPM-controlled third-harmonic generation in a hollow optical fiber: (1) modulus of the amplitude of the fundamental pulse at the input of the fiber, (2) the third power of the modulus of the amplitude of the input fundamental pulse, (3) chirped third-harmonic pulse at the output of the fiber, and (4) third-harmonic pulse after compression.

References

1. M. Nisoli, S. De Silvestri, and O. Svelto, *Appl. Phys. Lett.* 68, 2793 (1996); M. Nisoli, S. De Silvestri, O. Svelto, R. Szipöcs, K. Ferencz, Ch. Spielmann, S. Sartania, and F. Krausz, *Opt. Lett.* 22, 522 (1997).
2. C.G. Durfee III, S. Backus, M.M. Murnane, and H.C. Kapteyn, *Opt. Lett.* 22, 1565 (1997).
3. K. Ueda, H. Nishioka, W. Odajima, and H. Takuma, *Laser Phys.* 6, 1161 (1996).
4. N.I. Koroteev and A.M. Zheltikov, *Appl. Phys.B* (in press).

TuT25

Parametric amplification and second harmonic generation in anisotropic waveguides

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For increasing the amplification coefficient of SRS on polaritons in $LiNbO_3$ reflection of waves from side surfaces of the nonlinear elements was applied [1]. By this, the waveguide is symmetric and both partial waves of the waveguide modes interact with the pumping emission. The amplitude amplification coefficient G of one of the waves interacting parametrically in a slab of the thickness b and length d, is has the form $G(d) = K\,\mathrm{ch}(\gamma d)$. Excitation coefficient K depends on transverse structure of the amplified and pump beams and is close to unity if their diameters $D_1; D_3 \approx b$. Wave interaction coefficient γ is less than its value γ_0 for the case of plane pumping wave: $\gamma = m\gamma_0$; $m \leq 1$. The value of m depends on directions of the wave group velocities with respect to the waveguide side surfaces. E.g., under SRS at polaritons $m \approx D_3/b$; when the group velocities of the pumping and amplified waves are parallel to the waveguide walls which the runaway wave is reflected from, $m \approx D_3/(2^{1/2}b)$. By changing the directions it is possible to make the signs of the wave group velocity mismatches with respect to the parallel group velocity of the pump wave opposite. This allows generating pulses with the smaller length than that of the pumping pulse [2;3].

1. Babin, A. A. et al., Quantum electronics, 4, 433–436 (1977)

2. Sushik, M. M., V. M. Fortus, and G. I. Freidman, Izv. vysshikh uchebnykh zaved. – Radiofizika, 12, 293–297 (1969)

3. De Trapani, P., A. Adreoni, C. Solcia, P. Foggi, R. Danelius, A. Dubetis, and A. Piskarskas, J. Opt. Soc. Am. B12, 2237 (1995).

TuT26

Third-harmonic generation and resonance-enhanced multiphoton ionization in Bessel beams

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Last years so-called "diffraction-free" Bessel beams are of great interest. These beams are able to induce a variety of nonlinear effects, but in many cases these effects are manifested with significant differences as compared with the ordinary Gaussian beams. It results from the principal difference between these kinds of the beams, where nonlinear processes are driven either in a collinear (Gaussian beam) or a noncollinear (Bessel beams) excitation geometries. In the present report we consider the generation of third harmonic (TH) in tigthly-focused Bessel beams and influence of the TH photons on resonance-enhanced multiphoton ionization.

In experiments the Bessel beams with inclination angles ranging from 17° to 90° were used to study (3+2) and (4+1) resonance-enhanced ionization near the three-photon 6*s* resonance of xenon (435-441 nm). In this region an intense TH can be generated in xenon and the ionization spectra undergo significant transformations when a Gaussian laser beams is transformed into a Bessel one [1,2]. These transformations are caused by an internally-generated TH and an interplay between different excitation pathways, where the one- and the three-photon processes are involved. We present and discuss a number of experimental and numerical results concerning TH generation and a resonance-enhanced ionization in the Bessel beams: near-resonance suppression of ionization, generation of TH in self-phase-matching conditions, additional ionization by the TH photons, cancellation and enhancement of the atomic resonances.

1. V.Peet, Phys. Rev. **A53** 3679 (1996).
2. V.Peet and R.Tsubin, Phys. Rev. **A56**, 1613 (1997).

Noncollinear excitation geometry of a Bessel beam results in several specific features of nonlinear optical phenomena. We report experimental observations and numerical analysis of third-harmonic generation and resonance-enhanced multiphoton ionization of xenon in tightly-focused Bessel beams.

TuT27

CONSECUTIVE QUASI-PHASE-MATCHED INTERACTIONS OF LIGHT WAVES

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Recently we have shown that in media with periodically modulated nonlinear susceptibility it possible to accomplish collinear quasi-phase-matched (QPM) interaction of three waves of frequencies ω, 2ω, 3ω and degenerate interaction of frequencies ω and 2ω simultaneously [1]. This provides the conditions for effective realizing of consecutive collinear nonlinear processes.

We report on results of investigation of such new type of QPM interactions. Analysis was made for the cases of both co- and counterpropagating interacting waves. We obtained expressions for amplitudes of interacting waves in the approximation of a undepleted pump-wave field. For general case of effective energy exchange between interacting waves we fulfilled numerical calculations. It has been demonstrated for copropagating wave interaction that consecutive three-frequency interactions can result in highly efficient conversion of the energy of the intensive pump wave of frequency 2ω to the energy of signal wave of frequency 3ω (parametric amplification of wave with low-frequency pump). It was also established that dynamics of the interacting waves depends on many parameters: on the ratio of initial intensities of pump and signal, on the initial phase relationship between them as well as on relationship between nonlinear coupling coefficients of the waves. *This process reveals switching properties, when* small variation of initial conditions can lead to considerable change of output intensity of signal wave.

In the case of counterpropagating waves the effective energy conversion possible as well. We considered dynamics of counterpropagating wave interactions when a backward wave had frequency ω or 2ω. QPM conditions were found for consecutive co- and counterpropagating interactions in periodically poled $LiNbO_3$ crystals.

1. A.L.Aleksandrovski, A.S.Chirkin, V.V.Volkov, *J.Russ.Las.Res.*, 18, 101 (1997)

TuT28

TRAVELLING WAVE OPO WITH BESSEL PUMP BEAM

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The present paper is devoted to investigation of optical parametric amplification of travelling waves (TW) with Bessel pump beam, which has a quasi-nondiffractive nature. Earlier the SHG by Bessel beam in a bulk crystal was considered in [1]. We study the parametric conversion efficiency and signal beam width narrowing in TW OPO with both Bessel and Gaussian pump beams by numerical simulation. We put Gaussian beam confocal parameter equal to nonlinear crystal length. The Bessel pump beam is formed from this optimal Gaussian one by an axicon lens.

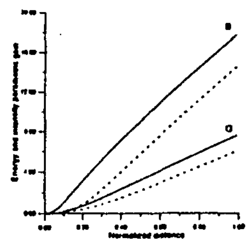

Fig. 1. Parametric gain vs distance.

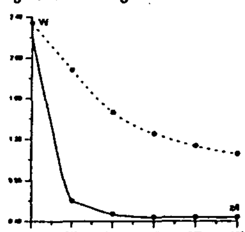

Fig. 2. Signal width vs distance with Bessel (solid) and Gaussian (dashed) pump.

Parametric interaction of diffracted beams is governed by the set of three coupled nonlinear equations for envelopes [2], which is solved numerically.

Fig. 1,2 show the numerical simulation results for OPO with Bessel and Gaussian pump beams of equal power. One can see, that the signal gain and width narrowing are essentially larger with Bessel pump due to strong localisation of the optical fields near the beam axis.

References:

1. K. Shinozaki, Ch. Xu, H. Sasaki and T. Kamijoh, Opt. Commun. 133, 300 (1997).
2. A.P. Sukhorukov, *Nonlinear wave interactions in optics and radiophysics* (Nauka, Moscow, 1988).

TuT29

NONLINEAR OPTICAL LOOP MIRROR OPERATING BY NONLINEAR POLARISATION ROTATION

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Nonlinear Optical Loop Mirror (NOLM), whose operation relies on self-phase modulation, is used for fiber laser mode locking, for switching, for logic gates. The basic concept of the NOLM is based on the differential nonlinear phase shift between the counter-propagating, linearly-polarised light beams in the loop interferometer. Such an NOLM has a high reflection coefficient at low power and provides nonlinear switching by an asymmetrical coupler, i.e. one in which coupling coefficient differs from 0.5/0.5. The nonlinear polarisation rotation is allowed in addition to self-phase modulation as elliptically polarised beams propagate through the fiber. The terms describing this effect oscillates with frequency proportional to fiber birefringence and commonly is ignored for hi-bi fibers. For low birefringence fibers nonlinear polarisation rotation is important and is used, for example, for fiber laser modelocking in the ring configuration (1). Nevertheless for NOLM this effect was not considered.

We present the results of the simulation of the low birefringence NOLM with nonlinear polarisation rotation included. We find the nonlinear switch for symmetrical configuration with 0.5/05 coupler if the fiber is twisted or circular retarder is included into the loop. The NOLM in this configuration manifests unusual properties. One of the most exiting is polarisation independent operation. The unusual properties promise new applications of the considered configuration for switching and modelocking of fiber lasers.

1. M. E. Fermann. Nonlinear polarization evolution in passively modelocked fiber lasers. In Compact Sources of Ultrashort Pulses, ed. by I. N.Duling III, Cambridge Un..Press 1995

TuT30

Temporal Response of Photorefractive Two Beam Coupling to Slowly Oscillating Signals

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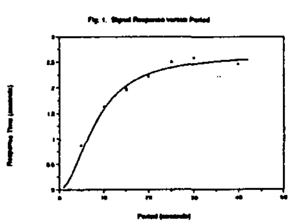
SUMMARY

We have been investigating the case where the input signal consists of a temporally modulated component, viz;

(1) $$A_1(0,t) = A_{10} + A_{11}e^{-i\omega t}$$

Our current investigations involve those cases in which $A_{11}/A_{10} < 0.05$ and $\omega < \tau^{-1}$. An analytic solution to the two beam coupling equations for the signal amplitude is;

(2) $$A_1 = A_{10}\exp\left[\left(\gamma - \frac{\alpha}{2}\right)z\right] + A_{11}\exp\left[\left(\frac{\gamma}{1+\omega^2\tau^2} - \frac{\alpha}{2}\right)z - i\omega\left(t - \frac{\gamma z\tau}{1+\omega^2\tau^2}\right)\right]$$



Eq. 2 demonstrates that a modulated signal experiences a time delay upon amplification. This time delay is the response time for two beam coupling. It is shown to be dependent on the modulation frequency, ω, of the input signal. For low frequencies or longer periods, the response time is given by the product of the exponential gain, γz and the intrinsic response time. This is consistent with other observations previously reported (1). For higher frequencies or shorter periods, the response time is expected to decrease with the square of the input period. In addition, the modulated signal experiences a gain which is also dependent on the input frequency.

We have measured the delay time and the relative gain for two beam coupling in rhodium doped barium titanate. In Fig 1, the delay versus period is shown. The measured delays were fit to a curve of the form given in Eq. 2.

1. D. Statman, G.C. Gilbreath, M.Statman, and C. Stefanini, J. Opt. Soc. Am., B,(in press).

TuT31

DISTRIBUTED FIBER SENSOR BASED ON DISPERSION OF BIREFRIGENCE

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The optical-fiber-based sensors have a wide range of applications. However, the integration of an array of such sensors has been difficult with the existing wavelength-multiplexing[1] techniques because of high system complexity and cost.

In this report we employ wavelength division technique for distributed sensing of stress-induced birefrigence in polarization preserving fiber. Measured mechanical stress must be oriented at angle 45 deg to principal axes of fiber. The main principle can be explained as follows. If at fiber input angle between the light polarization and the principal axes is 45 deg (fig.1), there is an alternation of circular and linear polarization states in fiber. Stress-induced birefrigence localized at points with linear polarization do not result in polarization changes at fiber exit. Distribution of polarization sensitivity along fiber has sinusoidal form shown in fig.2. Period of this distribution is determined by birefrigence of unpertubed fiber and hence depends on wavelength. Figure 3 shows the dependencies of phase shift between eigenmodes on fiber length at the Ar^+-laser wavelengths 514nm and 496nm. The phase shift divisible by π was defined by number of insensitive point. So, the ratio of contributions of different stress points in polarization changes differ for different wavelengths. One can obtain information about N mechanical stresses in N points of fiber by measurement of polarization changes at N wavelengths

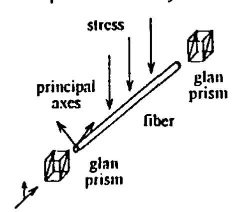

Fig.1

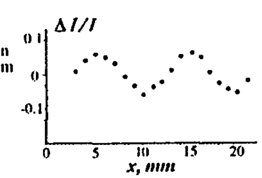

Fig2

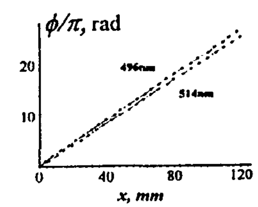

Fig.3

The proposed technique was verified for the case of N=3. The stresses in three points were recovered by measurement of polarization changes at wavelengths 514nm, 496nm and 476nm.

1. R.Duratians, G.Anglaret, C.J.Hugues, G.W.Fehrebach, in *Optical Fiber Sensors*, H.J.Arditty, J.P.Dakin, and R.Th.Kersten, eds., V.44 of Springer Proceedings in Physics, 1989, pp.504-512.

TuT32

Generalized reciprocity relations for nonlinear optical susceptibilities and their consequences

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M.A.Novikov, V.V.Ivanov
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The well-know symmetry relations for nonlinear optical susceptibilities for media without absorption are spread to media with dissipation, spatial dispersion, and magnetic order. The generalized relations are derived on the basis of rigorous quantum mechanical approach described in [1] which takes into account the microscopic time reversibility and basic principles of statistical physics.

As shown in [1], there's no any symmetry relations for quadratic and cubic susceptibilities if the dissipation presents at all frequencies. However if absorption is absent at one or more frequencies (or their combinations) the "reduced", less strict symmetry relations may be pointed out. In the spirit of known Neter theorem, every case of "reduced" symmetry corresponds to the certain Manly-Rowe type photon number conservation relations. The detailed analisys of "reduced" symmetry in quadratic and cubic media is given.

Symmetry relations for nonlinear light scattering are obtained. The generalized permutation relations are obtained which include the above mentioned nonlinear symmetry relations as well as fluctuation-dissipation relations. The partcular cases of Stockes and anti-Stockes scattering in cubic media are discussed in details.

Symmetry relations in media with spatial dispersion and magnetic structure are derived. With these relations, parametric optical effects in constant electric and magnetic fields are considered. The links between direct and inverse effects are shown. Particularly, it is shown that known electrogyration effect and magnetochiral effect corresponds to inverse effects of electrization and magnetization by an optical field if the absorption in a medium is absent.

1. G.F.Efremov and M.A.Novikov. Symmetry of nonlinear succeptibilities in absorbing media, *Laser Physics*, 4, 112-123 (1994)

TuT33

CONVERSION OF THE WIDE-BAND HEAT RADIATION IN CRYSTALS OF THE CLASS mm2

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One of the most important problems of nonlinear crystallooptics is establishment of interdependence of nonlinear properties of crystalline medium with features of its molecular structure and structure of unit cells. The report presents principal characteristics of conversion (spatial direction of synchronism, effective nonlinear coefficient, angle of deflection, angular and spectral widths of synchronism, parameters of quality) of wide-band radiation (0,8...2,8 μm) on frequency in biaxial crystals of class mm2: $KB_5O_8{\cdot}4H_2O$, $LiCOOH{\cdot}H_2O$, $Ba_2NaNb_5O_{15}$, $KTiOPO_4$, $KNbO_3$. These crystals are belong to orthorhombic system. With quasiidentical structure of crystals of class mm2 there exists considerable difference at the structure of Brave's gratings. Four types of Brave's gratings are distingueshed in the crystals of orthorhombic system: primitive, face-centered, base-centered, volume-centered. One may suppose, that differences in physical and chemical, and as well as in nonlinear-optical properties of the mentioned crystals are directly linked with the structure of theirs unit cells (with Brave's gratings in particular). In this report an interdependence between the above mentioned parameters of the crystals and theirs inner structure is established, the most suitable biaxial crystal for parametric up-conversion of frequency nonmonochromatic IR radiation to visible field of spectrum 0,4...0,7 μm with using of wide-band nonlaser pumping is selected, its optimum geometry is defined.

TuT34

Some features of growth and decay of second order polarizability gratings in lead glasses

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Photoinduced second harmonic generation (SHG) via $\chi^{(2)}$-gratings in optical fibers [1] and bulk glasses [2] is attractive phenomenon because of its mysterious origin and potential applications. Lead glasses seem to be the most promising materials for frequency doubling and information storage devices.

We report the observation of efficient photoinduced SHG in lead-phosphate glass with a high (46 mol. %) PbO-content. Efficiency of conversion to second harmonic was about 10^{-8} after preparation by 10 pulses of Nd:YAG Q-switched laser (the same order of magnitude of conversion efficiency has been found in the best lead-silicate glass ZhS-4 under the same conditions). The investigation of lead-phosphate glasses is interesting because the structural state of lead in these glasses is quite different from its state in lead-silicate glasses.

Owing to high efficiency of the lead-phosphate glass it turned out possible to write $\chi^{(2)}$-gratings by *single pulse* of 50 ns duration. After writing the gratings were exposed by fundamental frequency radiation of the same power ($\sim 10^3$ shots). The decay rate was different for gratings written by the single pulse and by several dozens of pulses, but the SHG was reduced rather slowly in each case.

We studied the growth of induced SHG in lead-silicate and lead-phosphate glasses. Linear dependence of second harmonic power on pulse number has been observed in both glasses in the initial stage of preparation (20-60 shots). It was suprising because earlier [2] quadratic dependence on the time had been observed in lead-silicate BS-7 using cw Q-switched mode-locked laser radiation.

We hope that the results obtained can be used in exploitation of devices for information encoding on the base of photoinduced SHG.

1. U. Osterberg and W. Margulis, Opt. Lett., 11, 516 (1986).
2. V.M.Churikov, Yu.E.Kapitzky, V.N.Lukyanov and B.Ya.Zel'dovich, Sov. Lightwave Commun., 1991, 1, 389 (1991).

TuT35

COHERENT ANTI-STOKES RAMAN SCATTERING FROM POLARITONS WITH SPATIAL SEPARATION OF THE EXCITING AND PROBE BEAMS

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We have performed experiments using CARS configuration (fig.1) in which the regions of excitation of polaritons(A) and probing(B) of excited polaritons are spatially separated in a crystal [1]. This technique is used to eliminate background which appears in the signal of CARS from polaritons due to four-photon processes (Fig.2). The background disappears in this configuration, since four-photon processes are possible only when all three beams incident on the crystal overlap spatially.

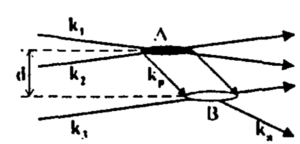

Fig.1 Principle of the experiment. $k_1(\omega_1)$, $k_2(\omega_2)$, $k_p(\omega_1-\omega_2)$, $k_3(\omega_1)$, and $k_a(\omega_a)$ are the wave vectors of the laser, Stokes, polariton, probe and CARS beams.

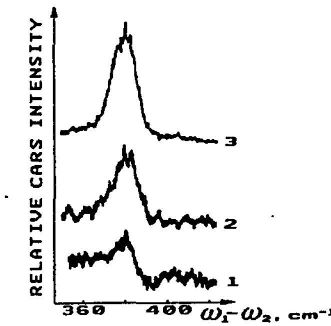

Fig.2 Polariton CARS spectra of a BeO crystal recorded at different distances d between probing and excitation regions: (1) d=0, (2) d=0.75a, (3) d=1.5a, where a≈270μm is a diameter of the laser beams. The interference between polariton and four-photon contributions is eliminated with increasing of d, and undistorted line shape is obtained. Experiments were carried out with lasers of ns pulse duration.

We also measured the spatial loss of coherence of the polariton packet in BeO crystal by scanning displacement d and detecting the amplitude of anti-Stokes signal. For example, the length of the loss of coherence of the polaritons of frequency 390cm^{-1}, measured by this way, is about 0.3mm.

1. G.M.Gale, F.Vallee,C. Flytzanis. Phys.Rev.Lett. 57,1867 (1986).

W E D N E S D A Y

1 July 1998

SESSIONS:

WA - Plenary Lectures II
WB - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics I
WC - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures I
WD - High-Precision Measurements in Optics I
WE - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine I
WF - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics I
WG - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics II
WH - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures II
WI - High-Precision Measurements in Optics II

SESSIONS:

WJ - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine II
WK - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics II

Poster Session:
WL - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics
WM - Fundamental Aspects of Laser-Matter Interaction II
WN - High-Precision Measurements in Optics
WO - Nonlinear Optical Phenomena II

Plenary Lectures II

Presider: *S.N. Bagayev, Inst. Of Laser Physics, Russia*

8:30-9:00 **CONFERENCE HALL**
WA (Plenary Lecture) - Ultrafast technology: Recent achievements and perspectives
S. DeSilvestri, Dipartamento di Fisica, Politecnico, Italy

9:15-10:00 **CONFERENCE HALL**
WA (Plenary Lecture) - New effects of atomic coherence in laser physics and quantum optics
M.O, Scully, Texas A&M University,USA

WA1

WA2

13:30-16:15 **GREEN HALL**

WB - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics I

Presider: *A.M. Zheltikov, M.V.Lomonosov Moscow State Univ., Russia*

13:30
WB1
(Keynote)

LINEAR AND NONLINEAR OPTICAL PROCESSES FOR IMAGING COMPLEX FLOWS

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A full evaluation of complex flow properties requires both scalar (pressure and temperature) and vector (velocity) fields. These fields need to be acquired at an instant in time with high spatial resolution in order to avoid both temporal and spatial averaging. Imaging by molecular light scattering from a high power laser is presented as a method to meet this challenge. Earlier work has used foreign species such as sodium or iodine seeded into air for the measurement of these quantities via laser-induced fluorescence. The complexity of the laser-induced fluorescence process, including quenching and laser saturation, together with the difficulty associated with the dynamic seeding of reactive species into air, has made this approach, for the most part, unsatisfactory. The laser-induced fluorescence approach is now being replaced by two complimentary approaches for scalar and vector field measurements: Filtered Rayleigh Scattering (FRS) and RELIEF (Raman Excitation + Laser-Induced Electronic Fluorescence) flow tagging. The Filtered Rayleigh Scattering approach requires a laser with a high enough pulse energy to generate sufficient Rayleigh light scattering from the air molecules in the flow. This scattered light is collected with a lens collection system, passed through a very narrow linewidth atomic or molecular gas filter, and imaged onto a camera. The laser is tuned in the vicinity of the absorption feature of the atomic or molecular gas filter, and, by comparing the light passed through the filter with the total scattering, the lineshape and strength of the Rayleigh scattering can be ascertained. Since the species in air are known, these signals can be inverted to give density and temperature fields. Rayleigh scattering can also be used to image velocity via the Doppler shift. A more accurate method of measuring the vector field is to use stimulated Raman scattering to vibrationally excite oxygen molecules along a line or in a pattern. These vibrationally-excited oxygen molecules then convect with the flow and are interrogated via laser-induced fluorescence, a short time later. The displacement of the line or pattern then becomes a measure of the transport properties of the flow field itself. This is a particularly good approach for measuring turbulent structure, since the fact that the tagged molecules convect with the flow eliminates errors associated with stationary point measurements of highly turbulent flow fields. Flow tagging has also been extended to water flows through the use of ultraviolet, activated organic dyes that are seeded into the water at levels on the order of a few parts per million. In a manner similar to RELIEF flow tagging, the organic dye is activated by an ultraviolet laser beam which writes a line or pattern into the flow field. At a later time, the field is illuminated with an interrogation laser, and the activated molecules fluoresce.

The filter approach to Rayleigh scattering is also extended to Raman imaging by either using an atomic vapor filter and looking for refluorescence, or by building an atomic vapor prism cell and using the dispersion to separate out the rotational lines. These approaches have both given high sensitivity, and single rotational line imaging capabilitiy.

14:15
WB2
(Invited)

FOUR WAVE MIXING SPECTROSCOPY: MEASUREMENT OF FLAME TEMPERATURE, CONCENTRATION AND FLOW VELOCITY

P. Ewart, R. Bratfalean, G.M. Lloyd, D.J. Walker and R.B. Williams
Oxford Institute for Laser Science, Clarendon Laboratory, University of Oxford, Oxford OX1 3PU, U.K.

Spectroscopy of transient or minor species created in hostile environments such as flames and plasmas presents technical challenges that are being met by non-linear optical techniques. We report on the potential of Four Wave Mixing, FWM, using both *population* and *thermal* gratings, for high resolution molecular spectroscopy and for diagnostics of combustion and non-combusting flows.

We have *extended the standard perturbation theory* of degenerate FWM which treats monochromatic laserswith a weak, i.e. non-saturating, probe [1], to deal with the more common situation where the signals are maximized by using saturating pump *and* probes. We have derived an analytical expression for the signal intensity in such cases which agrees with a full, non-perturbative numerical calculation. In the unsaturated case we include the effect of finite laser bandwidth and simulate complex molecular spectra for comparison with experimentally determined FWM spectra of C_2 in an oxy-acetylene flame.

We have also simulated theoretically the spectral density of broad bandwidth or multiplex FWM signals for comparison with experimental data used for single-shot thermometry of flames[2]. Analysis of spatially resolved spectra, generated using sheet-like pump and probe beams from a broad-band, modeless, laser provides temporally and spatially resolved temperature and concentration along a *line in the flame*.

We report a novel technique for velocimetry using *thermal* gratings induced in a gas flow. The thermal grating, being a feature of the bulk gas, moves with the gas flow velocity and so when a delayed probe is scattered *from the moving grating*, an interferometric measurement of the resulting Doppler shift yields the gas velocity in a single laser shot. This Thermal Grating Velocimetry, TGV, provides time and space resolved measurements in agreement with values obtained by a conventional pitot tube.

[1] R.L. Abrams and R.C. Lind, Optics Lett. **2**, 94 (1978) and **3**, 205 (1978)
[2] C.F. Kaminski, I.G. Hughes, G.M. Lloyd and P. Ewart Appl. Physics B, **62**, 39 (1996)

14:45
WB3
(Invited)

IMAGING IN TURBID MEDIA BY SELECTIVE FEEDBACK IN A CLASS B LASER

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Visibility in diffusing media is an important goal in many fields. Here we present preliminary results obtained with a new method, similar to that used in a heterodyne scanning *confocal microscope*, where a laser source acts at the same time as an optical amplifier for the detection in order to improve the detectivity.

A short laser cavity, for which the lifetime of the photons in the cavity is shorter than the lifetime of the population inversion (Class B laser), exhibits for the intensity fluctuations, strong resonances at one or more frequencies F_r. Such a type of laser shows a high sensitivity to optical feedback.

The principle of our method is based on the optical amplification of a retro-diffused beam shiffted at one of the resonance frequencies of the laser. The beam of the laser is first shifted in frequency and focused into the turbid media under investigation. Only ballistic photons coming for the vicinity of the focal point are re-injected into the laser cavity. The light scattered back from the other part is rejected. The resulting beat at the resonance frequency is amplified by the laser and detected on *the intensity of the laser* by a photodiode and a lock-in amplifier. The gain in signal, compared to the one obtained in a classical confocal experiment, can be theoretically as high as 10^6 for a microchip laser and 10^3 for a diode laser. The sensitivity can be adjusted by tuning the frequency more or less to the center of the resonance frequency.

A *800 microns thick* Nd^{3+}:Yag microchip laser pumped with a diode laser was used. The resonance frequency is about one megahertz. Preliminary results were obtained with different objects covered by a few centimeters of milk, an excellent and cheap diffusing medium.

We demonstrated the possibility of generating images through turbid media by a new method. This method, similar to a confocal microscopy technique, is based on the enhancement of the sensitivity due to a selective feedback in a mini-laser. The advantages are an automatic optical alignment, a high spatial resolution and a high sensitivity due to the optical amplification by the laser.

15:15
WB4
(Invited)

The challenge of non-linear vibrational spectroscopy in small volumes. How small can it get?

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Today's technologies are reaching for the application of smaller and smaller amounts of material. These may be nano-sized structures, micro-cavities, domains at surfaces or single molecules. Under all these very subtle circumstances it is often not easy to obtain detailed material information. Vibrational spectroscopy, in principle, is one of the methods that is capable of material characterization and dynamical studies. Ultimately, a technique should be developed that is capable to detect, characterize and study materials in very small volumes, using vibrational information. Spontaneous Raman microspectroscopy is to date the technique that is most developed. Small numbers of molecules can already be observed.

We have furthermore conducted CARS experiments using microscope objectives to focus the incoming laser beams and to collect the CARS beam. Employing a head-to-head arrangement of the objectives a simple set up results, in which phase-matching is fully relaxed. This measurement scheme can be easily combined with polarization sensitive measurements and a broad band nature of the Stokes and CARS laser beams. We have used this set up to look into the 4-wave-mixing vibrational spectra of molecules that are important as model systems for biological molecules and of molecules that are highly fluorescent. High quality polarisation sensitive CARS spectra can be obtained in this way.

We have also looked into possibilities to obtain vibrational spectra of monolayers of molecules with lateral resolutions that are close to the diffraction limit. Particularly, vibrationally resonant sum frequency generation will be considered as an important method. Considerations to build a device that is capable to obtain vibrational spectra of very thin layers by this method will be presented. In order to circumvent damage to the samples the energy distribution must be optimized. Optimization concerns high repetition rate light sources and still sufficient peak power.

We will discuss instrumental developments that are ultimately aimed at detection and characterization of small numbers of molecules under ambient conditions using vibrational spectroscopic techniques. We will show experimental results of Raman imaging and Micro four wave-mixing.

15:45
WB5

INFRARED DEGENERATE FOUR-WAVE MIXING AND RESONANCE INHANCED STIMULATED RAMAN SCATTERING IN MOLECULAR GASES

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[2]General Physics Institute, Russian Academy of Sciences, Vavilova str. 38, 117942 Moscow, Russia

Infrared degenerate four-wave mixing spectroscopy (IR-DFWM) has been employed to study the molecules C_2H_2, CH_4, NH_3, HCl, CO_2 and N_2O in a cell under equilibrium conditions and cooled in a free jet expansions. The detection limit of 2×10^{12}molecules per cm^3 and quanyum state with spatial resolution of $1mm^2\times30mm$ was achieved for R(0) line in the v_3 band of CH_4 in a cell at room temperature.

At attempt to obtain the DFWM spectra in CO_2 and N_2O with pump of the v_1+v_3 and $2v_2+v_3$ combination bands we were not able to detect any DFWM signal. Instead a surprisingly strong, backward and forward directed stimulated emission was found which could not be attributed to the DFWM signal. The signal arising from this emission was more than 3 orders of magnitude stronger than the DFWM signal obtained for other molecules. The frequencies of the emitted radiation were found to correlate with the transitions $v_1+v_3\rightarrow v_1$ and $2v_2+v_3\rightarrow 2v_2$, respectively. Our investigations leads to the conclusion that the emission can be explained by stimulated Raman scattering, resonantly enhanced (RSRS) by transitions to the combination levels v_1+v_3 and $2v_2+v_3$. The RSRS threshold was fairly low. For example, the threshold pump energy per pulse was only 10μJ for CO_2 at pressure of 50mbar and it was possible to observe RSRS at low density under supersonic expansion of CO_2 gas in vacuum.

Apparently, the low-threshold RSRS, observed for some molecules (CO_2, N_2O), competed with the DFWM process, which could impose some limits on the applicabiliy of IR-DFWM as a general spectroscopic tool.

16:00
WB6

DIAGNOSTICS IN GASES BY TRANSIENT LASER-INDUCED ELECTROSTRICTIVE GRATINGS

B. Hemmerling[1], W. Hubschmid[1], D.N. Kozlov[2], and A. Stampanoni[1]
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Laser-induced gratings arise from the interference of two excitation beams intersecting each other in a medium. The interference produces a spatially periodic light intensity distribution which may change the complex refractive index of the medium by electrostriction. In this case, the electric field of the interference structure polarises the dielectric medium and the spatial inhomogeneity of the field causes a motion of mass towards regions of higher laser intensity. Thus, sound waves are generated, with the wavelength defined by the fringe spacing of the interference pattern. They propagate in opposite directions, normal to the planes of the fringes. The counter-propagating sound waves form a standing acoustic wave and thereby a spatially periodic density grating that oscillates in time. Laser induced gratings can be detected by scattering a laser beam off the grating. The scattering efficiency is high if the Bragg condition is satisfied. From the temporal evolution of the grating scattering efficiency one can infer the sound velocity in the medium. If the gas composition is known the measurement of the sound velocity allows to deduce the temperature. We evaluated the systematic and statistical error of the temperature measurement in a tube furnace up to 1370 K and performed preliminary temperature measurements in premixed flames. On the other hand, if the temperature is known concentrations in isothermal, binary mixtures can be determined by the laser-induced grating technique. In methane/nitrogen and hydrogen/nitrogen mixtures we determined the limits for the minimum detectable variation of the gas composition at 0.5 mole fraction to be 2% and 0.8%, respectively. Furthermore, we will present an experimental setup which allows the generation and temporal resolved detection of laser-induced electrostrictive gratings by a single, pulsed Nd:YAG laser.

13:30-16:15 **RED HALL**

WC - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures I

Presider: *A.A. Manenkov, General Physics Inst., Russia*

13:30
WC1
(Keynote)

NANOOPTICS

V.S.LETOKHOV

Institute of Spectroscopy, Russian Academy of Sciences

The lecture will discuss in a unified way the following problems, which are part of a new trend in optics – optics on a nanoscale (nanoholes, nanoslits, nanospheres, nanotips etc):

(a) Localized near-field for various types of microscopy, including contact-type [2] and a combination of the near-field microscopy (AFM) and FRET (Forster resonance energy transfer) techniques with a resolution of 1-2 nm [3];

(b) Properties of atomic dipoles (radiative width and spectral line shift) inside and outside of a nanosphere [4], including the vacuum Rabi splitting [5];

(c) Radical change of the quadrupole transition probability in the vicinity of a nanosphere [6] and the dipole-dipole FRET properties at a curved nanoscale interface [7], which is important for FRET microscopy [3];

(d) Outlook: Laser Maxwell's Demon [8], superhigh density optical WROM [9] etc.

[1] *Near Field Optics*, eds. D.W.Pohl and D.Courjon (Kluwer, Dordrecht, 1992).

[2] D.A.Lapshin, V.V.Reshetov, S.K.Sekatskii, V.S.Letokhov. JETP Lett. (in press).

[3] S.K.Sekatskii, V.S.Letokhov. JETP Lett. 63, 319 (1996).

[4] V.V.Klimov, M.Ducloy, V.S.Letokhov. Journ. Mod. Optics, 43, 549 (1996); 43, 2251 (1996).

[5] V.V.Klimov, M.Ducloy, V.S.Letokhov. Journ. Mod. Optics, 44, 1081 (1997); JETP 84, 24 (1997).

[6] V.V.Klimov, V.S.Letokhov. Opt. Comm. 122, 155 (1996); Phys. Rev. A54, 4408 (1996).

[7] V.V.Klimov, V.S.Letokhov. Chem. Phys. Lett. (in press); Phys. Rev. A (submitted).

[8] V.S.Letokhov. Contemporary Physics, 36, 235 (1995).
V.V.Klimov, V.S.Letokhov. Optics Comm., 110, 87 (1994); JETP, 81, 49 (1995).

[9] V.S.Letokhov, S.K.Sekatskii. Optics Comm. (in press).

14:15
WC2
(Invited)

Linear and Nonlinear Optical Properties of Excitons in Semiconductor Quantum Wires

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Linear and nonlinear absorption of excitons has been observed at room temperature in GaAs, CdSe and InP quantum wires (QWRs) crystallized in transparent dielectric matrix (in crysotile asbestos nanotubes and in through empty channels of mica molecular filters).

The measured energies of exciton transitions in QWRs correspond to those calculated. The binding energies of excitons in QWRs surrounded by dielectric matrix (crysotile asbestos and mica in our case) exceed 100 meV. The increase of the binding energies of excitons in QWRs crystallized in dielectric matrix arises not only due to the quantum confinement but also due to the dielectric enhancement. The attraction between electron and hole becomes stronger because of the great difference in dielectric constants of semiconductor QWR and dielectric matrix.

Picosecond laser spectroscopy method (pump and probe technique – the measurement of differential transmission (DT) spectra using picosecond continuum as a probe beam) has been applied to investigate the physical processes leading to strong dynamic nonlinearities in semiconductor QWRs. It has allowed to exclude the background caused by the linear absorption of the bulk semiconductor (part of the semiconductor material was crystallized between the nanotubes of crysotile asbestos and as little islands on the facets of mica molecular filters) and to distinguish the changes of transmission that arise at high density of the excited excitons.

Different competing and coexisting physical processes leading to strong dynamic optical nonlinearities of the bulk semiconductors and QWRs allowed to explain the time–resolved DT spectra.

The dominant effect responsible for the observed bleaching of the exciton absorption in semiconductor QWRs (for heavy hole–electron, light hole–electron excitons in GaAs and InP QWRs; the holes of A and B bands–electron excitons in CdSe QWRs) has been revealed – phase space filling.

The great binding energies of excitons in QWRs crystallized in transparent dielectric, the possibility to change the energies of exciton transitions changing the diameter of QWR, strong and fast nonlinearity open new possibilities for the creation of "excitonic" optoelectronic devices that may operate at room temperatures.

14:45
WC3
(Invited)

Radiative Broadening of Coupled Excitons in Quantum-Well Structures

H. M. Gibbs, G. Khitrova, J. P. Prineas, E. S. Lee, C. Ell, and M. H|bner
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The dephasing of excitons in multiple quantum well (MQW) structures can be strongly influenced by coherent radiative coupling effects based on the exchange of resonant photons, which undergo multiple reflections and re-emissions inside the structure [1-3]. In MQW Bragg structures (where the distance between adjacent QW_s is exactly one half of the heavy hole exciton resonance wavelength inside the medium), radiative coupling results in the formation of a superradiant exciton/photon mode whose radiative decay rate is N-times faster than for a corresponding single QW; N is the number of coupled QW_s [3]. The spectral counterpart of this temporal accelerated decay is a broadening of the reflection (R) and transmission (T) spectra. We have performed linear spectral R and T measurements on Bragg-spaced InGaAs/GaAs QW_s of various N and compared them with linear dispersion theory. The linewidth of R(E) for N = 30 is dramatically broader (?2 meV) at the Bragg resonance than off resonance at 0.85 the Bragg spacing (?0.6 meV). So far as we know, this is the largest radiative coupling reported to date in a III-V Bragg QW structure, and it is similar to the strain-compensated II-VI results [4]. Good agreement with the amplitude and shape of R(E) is found with computations based on linear dispersion theory, demonstrating that the radiative coupling in Bragg QW structures can be treated as a constructive interference effect. Linear dispersion theory constructs R and T by working from boundary conditions at each interface required by Maxwell_s equations. Such an approach requires knowledge of the refractive index and absorption coefficient for each layer. For the GaAs barrier layers, we used a low-temperature wavelength-dependent refractive index; for the QW layers, we measured the absorption coefficient of the bare QW (at 0.85 the Bragg spacing to minimize radiative coupling distortions of Beer_s law [2]) relative to bulk GaAs and then computed the index changes by Kramers-Kronig transformations. A plot of the linewidth of R(E) versus N is a straight line as predicted in [1]; from that theory one can deduce from the slope a radiative linewidth of 0.05 meV for a single QW. Degenerate four-wave mixing is being used to study both the superradiant mode (the only radiatively coupled mode in a perfect Bragg QW structure) and the N-1 subradiant modes which obtain finite oscillator strength when the spacing deviates from Bragg. From the latter one can place a lower limit on the nonradiative decoherence time of 20 ps. Support is acknowledged from AFOSR, COEDIP, DARPA/ARO, JSOP, and NSF.

[1] E. L. Ivchenko, A. I. Nesvizhskii, and S. Jorda, Superlattices and Microstruct. 16, 17 (1994).
[2] T. Stroucken, A. Knorr, P. Thomas, and S. W. Koch, Phys. Rev. B 53, 2026 (1996).
[3] M. H|bner, J. Kuhl, T. Stroucken, A. Knorr, S. W. Koch, R. Hey, and K. Ploog, Phys. Rev. Lett. 76, 4199 (1996).
[4] Y. Merle d_Aubigni, A. Wasiela, H. Mariette, and T. Dietl, Phys. Rev. B 54, 14003 (1996).

15:15
WC4
(Invited)

Nonlinear Optics of Random Nanostructured Materials: Composites, Clusters, and Thin Films

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Optical phenomena experience giant enhancements in fractal nanostructured materials consisting of small ~ 10 nanometer-size features. We studied nonlinear optical properties of fractal nanocomposites, rough self-affine surfaces, and random metal-dielectric films at the percolation. Nonlinear susceptibilities for fractal nanostructured materials were obtained both theoretically and experimentally.

In contrast to conventional (non-fractal) systems, the dipolar interactions in fractal objects are not long range; this results in localization of the optical modes at various random locations in a fractal object. The localized optical excitations of fractal objects form very sharp peaks, "hot" spots, with extremely high local fields in the peaks. The "hot" spots representing the eigenmodes of a fractal film are separated in space by distances much larger than the spot sizes. Accordingly, the local electromagnetic fields experience very large spatial fluctuations. Such pattern for the field distribution results in giant enhancements for nonlinear optical signals generated from molecules placed in the nanometer-size "hot" spots. The nonlinear signals per molecule from these "hot" spots exceed the background (average) nonlinear signal by many orders of magnitude. For the localized fractal modes, the local enhancements can reach values 10^{15} and larger, opening a fascinating possibility of the fractal-surface-enhanced nonlinear optics and spectroscopy of single molecules and nanoparticles.

Modern laser spectroscopy has already achieved extremely high resolution of 1 Hz and 5 fs in the spectral and time domains, respectively. By applying fractal thin films that increase drastically both the spatial resolution and signal level, the new field of nonlinear optical nano-spectroscopy can be developed, which could become an unique tool for studying nanosized materials and single molecules.

15:45
WC5
(Invited)

Laser Diagnostic of Nonequilibrium Charge Carriers in Silicon Quantum Wires

P.K. Kashkarov, V.Yu. Timoshenko

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For a successful application of quantum wells, wires and dots in the technology it is necessary to investigate in details the features of electronic and atomic processes in them. Porous silicon consisting of wires supporting a long range order in the atoms arrangement and having cross-sections of 1-5 nm seems to be a very convenient model object for the investigation. In the present work structure and electronic properties of porous silicon were studied by using of a complex of laser diagnostic techniques (second harmonic generation, Raman scattering, time resolved photoluminescence and IR-absorption). The concentration of surface defects was monitored by electron paramagnetic resonance. The experiments were carried out both in a vacuum and in an atmosphere of different gases and vapours.

A quantitative model based on the data obtained describing the dynamics of nonequilibrium charge carriers in silicon quantum wires is developed. According to the model the radiative recombination in such wires occurs through an annihilation of excitons for which the binding energy E_{exc} increases considerably (up to 300 meV) as compare to the bulk silicon (14 meV). Both, surface charged centers and dielectric properties of the ambients greatly influence on the value of E_{exc} in quantum wires. Specifically the binding energy lowers (that causes the photoluminescence quenching), after filling of the pores by a medium with high dielectric constant $\varepsilon > \varepsilon_{Si}$. This result is in a good agreement with our quantum mechanical calculations of E_{exc} for the exciton in a quantum wire embedded in a dielectric. A nonradiative recombination of charge carriers takes place through surface centers which concentration can be varied to a great extent under surface treatments (molecule adsorption, laser irradiation and so on).

This work was financially supported by Russian Scientific Programs "Physics of Solid State Nanostructures" (project 1-064), "Surface Atomic Structures" (project 96-1.33) and "Laser Physics and Laser Systems".

13:30-16:15 **BEIGE HALL**

WD - High Precision Measurements in Optics I

Presider: *W. Kiefer, Universitaet Wuerzburg, Germany*

13:30
WD1
(Keynote)

Precision Spectroscopy of Atomic Hydrogen

Theodor W. Hänsch

Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, und Sektion Physik, Ludwig-Maximilian-Universität, Schellingstr. 4, 80799 München, Germany

For almost three decades, the 1S-2S two-photon transition in atomic hydrogen with its natural line width of only 1.3 Hz has inspired advances in high resolution laser spectroscopy and optical frequency metrology. The resonance has become a *de facto* optical frequency standard. More imporantly, it is providing a cornerstone for the determination of fundamental physical constants and for stringent tests of quantum electrodynamic theory. In the future, it may unveil conceivable slow changes of fundamental constants or even differences between matter and antimatter.

Recently, we have observed this 1S-2S resonance with a line width of better than 1 kHz at 243 nm, i.e. with a resolution of 8 parts in 10^{13}. We excite the hydrogen atoms longitudinally in cold atomic beam; selecting slow atoms by their time-of-flight. The absolute resonance frequency is measured in a comparison with the microwave frequency of cesium atomic clock with the help of a novel phase-coherent laser frequency chain, using a transportable CH_4-stabilized He-Ne-laser at 3.39 µm as an intermediate reference. With the realization of a phase-locked chain of five frequency interval dividers we are demonstrating the viability of new approach to measuring the frequency of light.

The measured 1S-2S interval of $f_{1S\text{-}2S}$ = 466 061 413 187 . 34 (84) kHz represents now thew most accurate measurement of any optical frequency in the ultraviolet and visible range. Together with published data of other authors, we derive precise new values of the Rydberg constant, R_∞ = 10 973 731. 568 639 (91) m^{-1}, and the Lamb shift of the 1S ground state, L_{1S} = 8172. 876 (29) MHz. These are now the most accurate values available. [1)]

In a separate experiment[2)] we have measured the hydrogen-deuterium isotope shift of the 1S-2S two-photon resonance with a 150-fold increase in accuracy compared to the best previous experiments. The result of 670 994 334. 64 (15) kHz has been obtained with the help of an optical comb generator. From this measurement and a careful theoretical analysis, we derive values for the difference of the mean square charge radii of the proton and deuteron, $r_d^2 - r_p^2$ = 3.8212 (15) fm^2, and for the structure radius of the deuteron, r_{str} = 1.975 35 (85) fm. These results exceed the accuracy of electron-nucleon collider experiments by the order of magnitude and are in good agreement with recent theoretical predictions.

Two international collaborations are aiming at high resolution laser spectroscopy of antihydrogen atoms, in order to compare the spectra and gravitational acceleration of matter and antimatter. The status of our ATRAP project will be reported.

1) Th. Udem, A. Huber, B. Gross, J. Reichert, M. Prevedelli, M. Weitz, and T.W. Hänsch, Phys. Rev. Lett. 79, 2646 (1997)
2) A. Huber, Th. Udem, B. Gross, J. Reichert, M. Kourogi, K. Pachucki, M. Weitz, and T.W. Hänsch, Phys. Rev. Lett. 80, 468 (1998)

14:15
WD2
(Invited)

SLOW MOLECULE DETECTION, RAMSEY FRINGES, COLD ATOMS : WHAT ARE THE BEST CHOICES FOR OPTICAL FREQUENCY STANDARDS ?

Ch. Chardonnet, A. Amy Klein, L. Constantin

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During the last past years, a new generation of methods in ultra-high resolution laser spectroscopy have been developed with atoms and molecules. The very popular laser cooling and trapping techniques of atoms allow to perform interrogation times of a clock transition limited by gravity to one second or by the natural lifetime. This opens the possibility of ultra-precise measurements [1]. With this respect, the lack of laser cooling methods is an handicap for molecules. However, the rovibrational transitions represent a dense grid of very long-lived systems. The method of selection of slow molecules demonstrated with saturated absorption [2] as well as with Doppler-free two-photon spectroscopy [3] is a less efficient alternative to the laser cooling method for atoms. However, it is still unclear which method is able to provide the best optical transitions in terms of resolution and signal-to-noise ratio. The talk will be devoted to a discussion on the ultimate performances conceivable with the various methods for ultra-high resolution spectroscopy including the Ramsey fringes techniques.

We will remind the present state-of-the-art of the ultra-high resolution spectroscopy and we will discuss the size of the signals obtainable in realistic experiments for a given resolution. Then, we will attempt to propose optimized schemes for ultra-precise measurements in the optical domain.

[1] H Schnatz et al., Phys. Rev. Lett. **76**, 18-21 (1996)

[2] S.N. Bagayev et al., Rev. Roum. Phys. **33**, 361 (1988). Ch. Chardonnet et al., Appl. Phys. B **59**, 333-343 (1994).

[3] P.E. Durand, Europhys. Lett. **37**, 103-108 (1997).

14:45
WD3
(Invited)

High Precision Spectroscopy with Application to Optical Frequency References

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Significant progress has been made in the last few years in the development of high precision optical frequency references and in the technology for measuring optical frequencies. In parallel with other efforts around the world, at NIST we are exploring a number avenues in this direction. As part of this effort our group is developing an optical frequency/wavelength reference based on laser-cooled and -trapped Calcium atoms. Since the very promising early results of Bergquist and Barger the calcium system has shown excellent results in the work from Riehle et al. at PTB-Germany and other labs. Calcium's well known advantages, 400 Hz natural linewidth, freedom from perturbations from external fields, and compatibility with diode lasers makes it a particularly convenient and attractive optical reference. Less often mentioned are the serious disadvantages of low mass, and relatively high residual velocity even after laser cooling. Chris Oates and Francois Bondu in our group are working to explore its ultimate performance capabilities and limitations. With two systems now working we can compare the performance of a simple atomic beam against the laser-cooled calcium. Our present result s look very good, providing high signal-to-noise ratio Ramsey fringes as narrow as 1.5 kHz with the trapped calcium atoms. Frequency doubled diode lasers are used for cooling and trapping the calcium atoms from a short (12 cm) Ca atomic beam. We then apply 4-pulse time-domain optical Ramsey excitation with a stabilized red diode laser. Detection of the narrow red transition is either by red fluorescence or by absorption or fluorescence induced by a blue probe beam derived from the cooling laser. Another pulse of blue light from the cooling laser is used between the red pulses to remove one of the two recoil components.

We are also exploring and developing promising new technologies that should help to simplify the daunting challenges of synthesizing and measuring optical frequencies. The great advantage that we anticipate in frequency standards by using optical, rather than microwave resonances is severely limited by our present inability to measure optical frequencies at the required performance level of about)f/f=10-15. Combinations of advanced diode lasers and modern nonlinear optical materials allows use to reach wavelength ranges from the UV to the far-infrared. For example, with specially fabricated nonlinear crystals such as periodically-poled-lithium-niobate (PPLN) we have found some cases where single, nonlinear elements can be used to produce two sequential nonlinear mixings.

The work on optical frequency references at NIST is a collaborative program between a number of groups. This includes the outstanding results from J.C.Bergquist et al. on the Hg+ optical frequency reference, and J.L. Hall's research on the rubidium two-photon transition and the Nd-Yag laser stabilized to C2HD or I2. Our goal is to be able to connect and compare these various optical references and with eventual connection to the microwave Cs atomic clock.

15:15
WD4
(Invited)

Absolute frequency measurements in precision laser spectroscopy of muonium.

S.N.Bagayev, A.M.Belkin, A.S.Dychkov, S.A.Farnosov, N.V.Fateev, D.B.Kolker, Yu.A.Matyugin,
Institute of Laser Physics, Siberian Division of Russian Academy of Sciences, Novosibirsk, Russia.

High resolution two photon spectroscopy of the muonium 1S -2S transition provide excellent opportunities for testing bound state quantum electrodynamics (QED), searching deviation from standard theory, and for the further development of modern laser spectroscopy. Fundamental constant, for example the Rydberg constant and the mass of the muon, can be extracted with very high accuracy.

A laser radiation at 244 nm for two photon excitation the 1S-2S transition is produced by frequency tripling of Ti:Sa laser light at 732 nm. In order to utilise the advantages of the narrow natural line width of the 1S-2S transitions, and reach goal in precision, the muonium experiment requires an optical frequency standard. A frequency of the standard must be not then ±1GHz away from the expected resonance at 732 nm in muonium. A suitable reference line for that standard have been found in the absorption spectra of the iodine vapour heated to 600°C. The Ti:Sa laser was locked to the hyperfine component of R(26)5-13 line selected as a frequency reference for the standard. In order to measure an absolute frequency of the developed standard an optical synthesis chain has been build up. The frequency to be measured is synthesised from two secondary standard frequencies: a frequency of the diode laser at 795nm locked to the d hyperfine component of the D_1 ^{87}Rb line and frequency of the CO_2 laser locked to the CO_2 R(10) absorption line. The sum of the standard frequencies differs by about 8 GHz from the frequency of the iodine reference line. We have proposed a new method for measurement of that frequency difference. This method is based on the efficient production of microwave sidebands by direct modulation of the current of a diode laser that is operating with feedback from a diffraction grating. By modulating the diode laser with the frequency for about 4 GHz we obtained two sidebands with a frequency offset about 8 GHz. One sideband was used for locking the diode laser to Rb reference line and other for synthesising the measured frequency. With this frequency chain the absolute frequency for the iodine reference line has been measured with an accuracy of the order of 10^{-10}.

15:45
WD5
(Invited)

OPTICAL FREQUENCY MEASUREMENTS IN HYDROGEN AND DEUTERIUM DETERMINATION OF THE RYDBERG CONSTANT

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For several years, Doppler-free two-photon spectroscopy has been applied to the hydrogen atom in order to test quantum electrodynamics calculations and to improve the precision of the Rydberg constant. Since 1986, we have studied in Paris the 2S-nS/nD two-photon transitions (n=8 to 12). In our first experiments, the measurement was made by comparing the wavelengths of the hydrogen transitions with that of an iodine stabilized He-Ne laser at 633 nm. More recently, we have performed optical frequency measurements of the 2S-8S/8D and 2S-12D transitions in hydrogen and deuterium. In the first case, this measurement takes advantage of a near coincidence (40 GHz) of the 2S-8S/8D transitions with a new standard, a laser diode at 778nm stabilized on the $5S_{1/2}$-$5D_{5/2}$ two-photon transition of rubidium. In the case of the 2S-12D transitions at 750 nm, the splitting with the 778 nm standard is measured thanks a small frequency chain using a CO_2laser stabilized on the OsO_4 molecule.

To analyse these results, we have performed a least-square adjustement using together the $1/n^3$ scaling law of the Lamb shift and all the precise measurements in hydrogen and deuterium, *i.e.* the radio-frequency measurement of the 2S Lamb shift and the optical frequency measurements of the 1S-2S, 2S-8S/D and 2S-12S/D transitions. Finally, the uncertainty in the Rydberg constant is reduced to about 7×10^{-12}.

13:30-16:15 **PRESIDENT'S HALL**

WE - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine I

Presider: *V.N. Zadkov, M.V.Lomonosov Moscow State Univ., Russia*

13:30
WE1
(Keynote)

Collective Electronic Excitaitons in Nonlinear Spectroscopy of Conjugated Molecules and Biological Complexes

Shaul Mukamel
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Rochester, NY 14627

Connecting electronic-structure and optical properties of organic compounds is an important fundamental problem with numerous technological applications. The Collective Electronic Oscillators (CEO) approach makes it possible to calculate optical properties of very large molecules and directly relate them to charge distributions in excited states in real space, completely avoiding the calculation of many-electron eigenstates [1,2]. The CEO is based on the time-dependent reduced single-electron density matrix which carries the information necessary for computing all molecular polarizabilities and spectroscopic observables. The equations of motion for this matrix map the calculation of the optical response onto the dynamics of coupled electronic oscillators which represent the joint collective motions of electrons and holes and carry substantially less information than the many-electron eigenstates. In complete analogy with molecular vibrations, these electronic oscillators can be viewed as collective coordinates which represent the displacements of the electronic density matrix elements from their equilibrium (ground state) values [2,3]. Two-dimensional display of dominant oscillators makes it possible to easily identify the underlying coherence sizes and predict spectroscopic trends. Calculating the electronic oscillators constitutes the bottleneck for applying the technique to very large systems. The Density-Matrix-Spectral-Moments-Algorithm (DSMA) [1,3] is a numerically efficient scheme based on the Lanczos algorithm which overcomes this difficulty. It computes the set of effective electronic modes which provide the best approximation for the spectra with a fixed number of oscillators. This number may be increased at will, until satisfactory convergence is obtained. In practice, only a few modes typically dominate the optical response, and the DSMA converges very quickly, making it possible to compute optical spectra of very large molecules with hundreds of heavy atoms. The computational time (and memory) requirements of DMSA scale very favorably with system size: $\sim N^3$ (and N^2). Several applications of the CEO will be discussed. These include collectiveoptical excitations of Poly(p-phenylene vinylene) (PPV) oligomers [2], real-space two-dimensional analysis of electronic excitations in stilbenoid aggregates and acceptor-substituted carotenoids [3]; the origin, scaling, and saturation of second order polarizabilities in donor/acceptor polyenes and localized electronic excitations in phenylacetylene dendrimers. The ability to describe large conjugated systems as weakly coupled chromophores opens up the possibility of applying an effective Frenkel exciton picture towards the theoretical modeling of their optical response. Femtosecond spectroscopy of chromophore aggregates is calculated using equations of motion for the complete set of exciton variables required for the microscopic description of all spectroscopies which depend on the optical field up to the third order. Applications to the B850 system of the light harvesting complexes LH2 of purple bacteria, which is made out of a ring of 18 coupled chlorophylls [4,5] will be discussed. The various relevant exciton coherence sizes and their signatures in superradiance, pump-probe, photon echo, and four-wave mixing measurements will be discussed.

1. "Electronic-Coherence and Collective Optical Excitations of Conjugated Molecules," S. Mukamel, S. Tretiak, T. Wagersreiter, and V. Chernyak, Science 277, 781-787 (1997).
2. "Two-Dimensional Real-Space Analysis of Optical Excitations in Acceptor-Substituted Carotenoids," by S. Tretiak, V. Chernyak, and S. Mukamel, JACS, 119, 11408-11419 (1997).
3. "Multiple Exciton Coherence Sizes in Photosynthetic Antenna Complexes Viewed by Pump-Probe Spectroscopy," T. Meier, V. Chernyak and S. Mukamel, J. Phys.Chem. B 101, 7332-7342 (1997).
4. "Femtosecond Photon Echoes in Molecular Aggregates, by T. Meier, V. Chernyak, and S. Mukamel, J. Chem. Phys. 107, 8759-8774 (1997).

14:15
WE2
(Invited)

Solvation dynamics and solvent effects in quantum and classical systems

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Recent theoretical and numerical investigations have indicated both similarities and differences in the time evolution of classical and quantum solvation processes. The response of a polar solvent following a sudden change in the charge distribution of a molecular solute is essentially a classical process, and classical non-equilibrium statistical mechanics as well as classical molecular dynamics simulations have provided an adequate description of such processes. In contrast, electron solvation is a quantum process as is best exemplified by the non-adiabatic nature of electron solvation in water and methanol.

In the present talk I will review recent numerical work on quantum and classical solvation phenomena, focusing on the role played by different solvent degrees of freedom in these processes. In particular, new results that emphasize the role played by solvent translational modes in solvation will be presented:

(a) The phenomenology of electron solvation in polar solvents was investigated using a model polar solvent, a Stockmayer liquid characterized by a combination of Lennard-Jones and dipolar intermolecular interactions.[1] We find that while fluctuations in the electron ground and excited state energies are dominated by the electrostatic part of the electron-solvent interaction, these contributions mostly cancel in the fluctuations of the gap between these states. Consequently, gap fluctuations are dominated by the solvent translational modes. Implications of these observations on the dynamics of electron solvation are discussed.

(b) The dependence of classical solvation dynamics on the thermodynamic state of the (Stockmayer) solvent was studied, focusing on states which are representative of the liquid and vapor phases, of the neighborhood of the critical point and of the supercritical region of the solvent.[2] We find that both static and dynamical aspects of the solvation process are strongly affected by the density of the neat solvent. At highly compressible solvent states, i.e. low density and in the neighborhood of the critical point, the increasing role of solvent translations makes the solvation response increasingly non-linear. We also find that the proximity of the critical point can show itself when some equilibrium and dynamical characteristics of the solvation are studied as functions of density near the critical temperature.

[1] P. Graf. And A. Nitzan, J. Phys. Chem., 100, 18916(1996)
[2] P. Graf and A. Nitzan, *"Numerical simulations of solvation in simple polar fluids: Dependence on the thermodynamic state above and below the critical point"*, Chem. Phys., in press.

14:45
WE3
(Invited)

Cooperative processes in aggregated systems - primary evets in light harvesting complexes

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Excitonic processes in linear and cyclic aggregates will be discussed with respect to the understanding of the excitation and desactivation process as cooperative events on a femtosecond time-scale. The talk will span the bow from annihilation and higher excited states (two-photon enhanced processes) to the estimation of delocalization lengthes of excited state energy until the question which role non-Markovian processes in the solute-solvent interaction instantaneous after excitation play. The talk well be based on experimental and theoretical work and will give an overview of the material discussed in the literature concerning the cooperative processes in linear an cyclic aggregates.

1. E.Gaizauskas, K.-H.Feller, Two-photon resonance enhanced transients in femtosecond spectra of molecular aggregates, Photochemistry&Photobiology, 65(5), (1997)611-617
2. E.Gaizauskas, K.-H.Feller, R.Gadonas, Annihilation enhanced four-wave mixing in molecular aggregates, Opt.Comm. 118, 360-366 (1995)
3. K.-H.Feller, R.Gadonas, G.Jonusauskas, A.Puglys, C.Rulliere Cooperative effects in nonlinear optical spectroscopy of J-aggregates, in: Ultrafast elementary processes in chemical and biological systems, ed. By A.Tramer, American Inst. of Physics, AIP Conference proceedings 364, Woodbury, New York, 1996, pp.517-524
4. E.Gaizauskas, A.Berzanskis, K.-H.Feller, Effects of non-Markovian relaxation on femtosecond transients in (four wave mixing) differential absorption spectroscopy Chem.Phys. (in press)
5. E.Gaizauskas, K.-H.Feller, Nonperturbative analysis of the resonant third-order nonlinearity in linear aggregates, J.Phys.Chem. (submited)
6. R.Gadonas, K.-H.Feller, G.Jonusauskas, J.Oberle, A.Pugzlys, C.Rulliere Wavelength and intensity dependent transient degenerate four wave mixing in pseudoisocyanine J-aggregates, J.Chem.Phys., 106(20),8374-8383 (1997)
7. K.-H.Feller, R.Gadonas, A.Pugzlys, D.Mobius Near Resonant nonlinear optical properties of pseudoisocyanine J-aggregated Langmuir-Blodgett layers, Laser Chemistry 17, 123-137 (1997)

15:15
WE4
(Invited)

IR Multiple-Photon Excitation in Vibrational Quasicontinuum. The Role of Inhomogeneous and Homogeneous Broadening.

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The results of the studies into the spectral properties of vibrational quasicontinuum (QC) of XF_6 type molecules are presented, special attention being drawn to their relation to IR MP excitation of polyatomics. It is shown, that two main effects - statistical inhomogeneous broadening (SIB) and homogeneous broadening (HB) determine the shape of vibrational transitions in QC of these molecules. The theoretical approach [1] is developed to calculate the cross-sections of IR transitions in QC when SIB plays the dominant role. These calculations are performed for ν_3 and ν_1 modes of SF_6 and WF_6. The spectral contour of these transitions is found to be Gaussian, the width $2\sigma_0$ of it being changed e.g. for ν_3 mode of SF_6 from 9.9cm^{-1} for E_{vib}=7000cm^{-1} up to 33.6cm^{-1} for E_{vib}=30000cm^{-1}.The comparison [2] of calculated and measured *equilibrium* spectra of ν_1 mode in IR MP excited SF_6 for the wide range of vibrational temperatures T_{vib}=845÷1660K showed very good coincidence. These experiments proved the contribution of HB to the total transition bandwidth for ν_1 mode to be considerably lower as compared with SIB.The *nonequilibrium* distribution resulting from IR MPE was studied, too. The population distribution function (PDF) was determined for IR MPD excited SF_6. PDF width was found to be considerably narrower compared with Boltzmannian one. The model of IR MPE in QC was developed on the base of calculated cross-sections and used for simulations of MPE in SF_6. Other results apart, the comparison of calculated and measured MP absorption provided to evaluate the contribution of HB into the bandwidth of ν_3 mode transitions.

References

1. A.A. Makarov, I.Yu. Petrova, E.A. Ryabov, V.S. Letokhov J. Phys. Chem. 102A, 1438 (1998)
2. A.L. Malinovsky, A.A. Makarov, I.Yu. Petrova, E.A. Ryabov, V.S. Letokhov J. Phys. Chem. (in press)

15:45
WE5

NONLINEAR OPTICAL PHENOMENA IN BIOLOGICAL TISSUES

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Application of nonlinear optics in biology is very attractive from two points of view: 1) realization of multiquantum excitation and initialization of effective nonlinear photobiological reactions[1]: 2)application of various nonlinear spectroscopy methods for investigation of structural and functional features of biomolecules [2,3]. However, the intensive scattering of light in strong turbid organic media is seriously eliminating factor for the study of living systems by nonlinear optical methods. Under these circumstances more intensive and short laser pulses are required for observation of nonlinear effects in biological tissues. We report here about observation and study of:

1) two-photon induced fluorescence of rat muscles sensitized by hematoporphyrin derivative (HpD), chlorin e_6,(Chl) Zn tetrasulfonated phthalocyanine (Ph) and disodium salt of fluorescein at picosecond YAG:Nd laser (1064 nm, 40 ps, 100 MW/cm^2) excitation; 2) nonlinear decomposition of the dyes in sensitized tissues upon picosecond laser radiation (355 and 532 nm, 20 MW/cm^2, 35 ps,); second harmonic generation (SHG) of picosecond pulses (1064 nm, 2 GW / cm^2) in fibril proteins containing tissues (dermis, tendon, cartilage, etc.)

Fluorescence spectra of tissues and scattering light were registered using fiber-optic laser spectrofluorometer. Photobleaching of the dyes in tissues was observed at 355 and 532 nm picosecond excitation and it was shown that initial rate of fluores- cence quenching depended quadratically on the irradiation intensity.

The temperature dependence of the SHG was studied and a decrease in more than 30 times of efficiency of the second harmonic generation was registered in temperature interval of 59-64 C. Anisotropy of polarization and SHG efficiency in various types of animal tissues were revealed.

References

1. Andreony A., Gubbedu R., et al. Chem. Phys. Lett. 88 (1982) 37.
2. Koroteev N.I. JETP. 106 (1994) 1260.
3.Lenz P. Photochemistry & Photobiology. 62(2) (1995) 333.

16:00
WE6

"VIEWING" OBJECTS EMBEDDED IN SCATTERING MEDIA BY FREQUENCY-DOUBLING THE FOURIER-TRANSFORM OF THE IMAGE

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The quality of an image of an object embedded in a scattering medium is generally degraded because light signals in such a medium split into a coherent (ballistic) and an incoherent components, of which only the former one brings information of the object. Different techniques have been proposed to enhance the detection of the ballistic signal by selecting it in time, first by picosecond Kerr gating [1] and, till recently, by cross-correlation time gating, with femtosecond resolution, *via* non-linear optical interactions (namely, second harmonic generation [2] and parametric amplification [3]).

We made experiments in which the part of Nd laser pulses (either 1.2 ps at 1.055 μm or 19 ps at 1.064 μm) emerging undeviated from a 1-cm cell containing micellar suspensions of Intralipid (Pharmacia, Italy) at different concentrations were cross-correlated with the incident pulses in a non-collinearly phase-matched BBO type I crystal. By collecting the transmitted pulse under an angle of about 9 mrad and by measuring the frequency-doubled signal at different time-delays, we only detected signals due to ballistic photons. We believe that this efficient cancellation of signal at the delays at which only the diffuse component is expected, is due to selection in direction of the wavevectors of the transmitted waves rather than to the huge time-spread of the incoherent components. To prove that the signal we detect, in a time interval of duration equal to that of the incident pulse, is due to the coherent components, we inserted a needle of 0.78 mm in diameter in the cell and imaged the frequency-doubled far-field distribution with a CCD camera. For lipid concentrations of up 1.25% (transmission $<10^{-5}$), the camera displayed diffraction patterns of the needle, perfectly matching the calculated ones. The diffraction pattern at the fundamental wavelength was detectable for concentrations < 0.6%. Experiments with 10 ns pulses are in progress to prove our idea that optical gating is not essential for imaging through scattering media.

[1] L.M. Wang, P.P. Ho, C. Liu, G. Zhang, R.R. Alfano, Science 253, 768 (1991)
[2] K.M. Yoo, Qirong Xing, R.R. Alfano, Opt. Letters 16, 1019 (1991)
[3] E.Lanz, F.Devaux, G.Le Tolguenec, H.Maillotte, in *OSA TOPS on Adv. in Optical Imaging and Photon Migration*, Vol. 2, ed. R.R.Alfano, J.G.Fujimoto, pp. 99-102, 1996

13:30-16:15 **BLUE HALL**

WF - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics I

Presider: *V.M. Gordienko, M.V.Lomonosov Moscow State Univ., Russia*

13:30
WF1
(Keynote)

Using Strong Laser fields to Focus Molecules

P.B. Corkum[1], Hirofumi Sakai[1,2], A. Tarasevitch[1,3], J. Danilov[1,3], H. Stapelfeldt[1], R. W. Yip[1,4], C. Ellert[1], and E. Constant[1,5]

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2 Electrotechnical Laboratory, 1-1-4, Umezono, Tsukuba, Ibaraki 305, Japan
3 International Laser Centre, Moscow State University, Moscow, Russia
4 Departement de Chimie, Universite du Quebec Montreal, Montreal, Quebec, Canada H3C 3P8
5 Departement de Physique, Faculte des Sciences, Universite de Sherbrooke, Sherbrooke, Quebec, Canada J1K 2R1

Intense laser fields apply forces to molecules that are strong enough to control both the internal and external molecular variables. Experimentally, we study the control over the trajectory of a molecule using the force resulting from the gradient of the non-resonant laser induced Stark shift. This force arises from the gradient of the interaction of the laser-induced dipole moment with the laser field. The potential well that we measure are approximately 10 meV deep and we predict potential well depths of 50 meV or more for molecules and atoms at intensities where the ionization rate is less than 10^6 s^{-1}. We demonstrate laser induced forces with both 1.06 μm (YAG) and 10.6 μm (CO_2) light interacting with carbon disulphide (CS_2) and iodine (I_2) molecules and show that these light beams can be used as molecular lenses. By choosing two wavelengths and two molecules we emphasize the generality of the nonresonant dipole force. On one hand, we have chosen 1.06 μm to direct our thoughts towards future experiments where very small focal spots .5 μm are achieved. Such small focal spots will allow us to control the position of molecules with almost atomic scale precision. For example, we show that such exotic new devices as molecular quantum wires can be constructed. On the other hand, we have chosen 10.6 μm light since the interaction of intense infrared light with small molecules and atoms is especially simple. For example, we know that mid-infrared light should be the least intrusive strong field source for manipulating a small molecule. With infrared light, ionization, excitation and dissociation will all be minimized since resonances are unlikely to play a significant role in the multiphoton ionization of the molecule and it is well known that small neutral molecules cannot be efficiently vibrationally excited by mid-infrared light. Consequently, the maximum fields that we calculate by approximating multiphoton ionization by tunneling is appropriate for 10 μm light and may slightly overestimate the appropriate fields at 1.06 μm. To perform the experiment, iodine or carbon disulphide molecules from a pulsed molecular beam are injected into a vacuum chamber along a direction perpendicular to the flight-axis of a time-of-flight mass spectrometer. An intense YAG or CO_2 beam, travelling perpendicular to both the molecular beam and time-of-flight axis, interacts with the molecular beam. Those molecules that pass through the deflecting beam experience the laser induced dipole force. We label those molecules to be measured by placing the deflecting laser beam just upstream of the focus of a femtosecond diagnostic laser beam. The femtosecond pulse ionizes the molecules producing singly-charged molecular ions by non-resonant multiphoton ionization. Due to the highly non-linear nature of multiphoton ionization the measurement is confined to the high intensity region of the femtosecond beam. The femtosecond beam is focused to a smaller spot than the deflection beam. With our experimental procedure we have more than 10 resolution elements across the central portion of the focus of the CO_2 laser.Only molecules that come from the small nozzle (diameter 250 μm) and pass through the small focus of the probe laser 8 cm below the nozzle can be ionized by the CPM pulse. This ensures that the molecules that are studied initially have a very small velocity in the direction of the time-of-flight axis. Molecules that gain more energy from the deflection beam than the initial transverse energy spread are observable through a difference in arrival times of the singly-charged molecular ions compared to the arrival time without the deflection beam. By scanning the diagnostic beam with respect to the center of the deflecting beam focus the molecular deflection is measured as a function of the position inside the deflecting beam Our measurement is the molecular analogue of ray tracing in optics and we show the molecular beam will focus.

14:15
WF2
(Invited)

Status of the National Ignition Facility Project

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SUMMARY

Construction of the NIF facility began in July, 1997. The first 8-beam array will be installed by September 2001, and the first 48 beams will be available for target experiments in September 2002. The project will be officially completed in September 2003 with 96 beams available for target experiments the remaining 96 beams installed and in the process of activation.

The National Ignition Facility (NIF) is required to routinely deliver 1.8-MJ pulses at 350 nm with peak power of 500 TW, shaped appropriately for ignition targets. The laser for this facility will be a multipass neodymium glass laser containing 192, independent, 40x40-cm-aperture lasers arranged in 24 modules, each an array of 8 beams - four high and two wide. To maintain high cleanliness, components will be assembled in cleanrooms, transported to the laser bay in sealed, clean containers, and loaded into the laser support structure from the bottom. Each individual laser beam will be essentially identical to the existing Beamlet laser testbed at LLNL, thus giving high confidence in performance capabilities. NIF requires 7500 optics of 40-80 cm^2 dimensions and 30,000 smaller optics. Required production in a four year period greatly exceeds current production capacity. Recent development projects to address this issue include work by Schott Glass Technologies and Hoya Corporation on continuous melting of neodymium-phosphate laser glass, and extension of work begun at Moscow State University on fast-growth of KDP and DKDP crystals to produce 57x57x47 cm^3 crystals at growth rates of 10-20 mm per day.

NIF's target chamber will be a 10-m-diameter aluminum sphere, lined with boron carbide plates forming a protective "first wall". The KDP crystals, used for harmonic generation, as well as all other final optics will be located in the target vacuum chamber. NIF also will use a diffractive, "color-separation" gratings on each beam to divert residual first- and second-harmonic light away from the target, rather than relying upon color dispersion in the focus lens to accomplish this function as done on Nova. These features minimize thickness of the third-harmonic optics, thus permitting generation of short pulses with higher peak power, as requested by user groups.

14:45
WF3
(Invited)

INTERFERENCE STABILIZATION OF RYDBERG ATOMS: THEORY AND EXPERIMENT

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Interference stabilization is known [1] to arise due to light-field-induced Raman Λ-type transitions between neighboring Rydberg levels of an atom. In a sufficiently strong light field, these transitions provide coherent re-population of Rydberg levels. Field-induced transitions to the continuum from the re-populated Rydberg levels can interfere with each other, and this is a physical reason of interference stabilization of an atom. Various models used to describe this phenomenon in a simplified form are described. In the most modern version of analytical theory, the nonstationary Schrödinger equation (the initial-value problem) was solved with the help of the ideas of the quasi-classical approach [2]. Such a theory does not exploit many often used approximations, which hardly can be justified in a strong-field limit (e.g., the rotating wave approximation and the so-called pole approximation). Besides, in contrast with earlier theoretical works, the quasicalssical theory describes in a natural way the case of pulses with arbitrary envelopes. The results of model considerations are compared with the exact numerical solution of the Schrödinger equation [3] and with the results of the existing experiments [4], and a very good qualitative and, sometimes, semi-quantitative agreement is shown to occur.

REFERENCES:

1. M.V. Fedorov and A.M. Movsesian, J. Phys. B, 21, L155 (1988)
2. O.V. Tikhonova and M.V. Fedorov, Laser Physics, 7, 574 (1997)
3. E.A. Volkova et al., Zh. Eksp. Theor. Fiz., 113, 593 (1998)
4. J. Hoogenraad et al., Phys. Rev. A, 50, 4133 (1994)

15:15
WF4
(Invited)

RECENT DEVELOPMENTS AND APPLICATIONS OF THE R-MATRIX-FLOQUET THEORY OF MULTIPHOTON PROCESSES

C.J. Joachain

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The R-matrix-Floquet theory [1,2] is a non-perturbative method which can be used to analyze multiphoton processes occurring when atomic systems interact with intense laser fields. It is completely ab initio and is applicable to an arbitrary atom or ion, allowing an accurate description of electron correlation effects.

In this talk, a survey will be given of two recent developments of the R-matrix-Floquet theory. The first one is its extension to two-colour laser fields [3]. An application to doubly and triply resonant multiphoton ionization processes involving autoinizing resonances in magnesium [4] will be discussed. Of particular interest is the occurrence of laser-induced degenerate states [5] at relatively modest intensities. The second development is the extension of the R-matrix-Floquet theory to the calculation of harmonic generation rates [6], with applications to various atomic systems [7-8].

References

[1] P.G. Burke, P. Francken and C.J. Joachain, Europhys. Lett. **13**, 617 (1990), J.Phys. B **24**, 761 (1991).

[2] M. Dörr, M. Terao-Dunseath, J. Purvis, C.J. Noble, P.G. Burke and C.J. Joachain, J. Phys. B **25**, 2809 (1992).

[3] H.W. van der Hart, J. Phys. B **29**, 2217 (1996).

[4] N.J. Kylstra, H.W. van der Hart, C.J. Joachain and P.G. Burke, to be published.

[5] O. Latinne, N.J. Kylstra, M. Dörr, J. Purvis, M. Terao-Dunseath, C.J. Joachain, P.G. Burke and C.J. Noble, Phys. Rev. Lett. **74**, 46 (1995).

[6] R. Gebarowski, P.G. Burke, K. T. Taylor, M. Dörr, M. Bensaid and C.J. Joachain, J. Phys. B **30**, 1837 (1997).

[7] R. Gebarowski, K.T. Taylor and P.G. Burke, J. Phys. B **30**, 2505 (1997).

[8] M. Bensaid, M. Dörr and C.J. Joachain, to be published.

15:45
WF5

Paper is not available

16:45-18:30 **GREEN HALL**

WG - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics II

Presider: *R.B. Miles, Princeton Univ., USA*

16:45
WG1

How dark is the dark resonance in a Λ-system?

B. A. Grishanin and V. N. Zadkov
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D. Meschede
Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, D-53115 Bonn, Germany

Three-level atomic systems compared to their two-level counterparts display a much broader range of new effects as a result of coherence among the states induced by the radiation and quantum interference. Among them the coherent population trapping (CPT) is the most intriguing phenomenon, which is most conspicuous for the Λ-transition between two closely spaced long lived levels optically coupled to a third distant short lived level by two continuous coherent radiation fields. In absorption spectra coherent superposition of closely spaced levels leads to a very narrow dip of induced transparency or, equivalently, a *nonabsorbing* dark resonance when resonance fluorescence is observed.

Any process destroying the coherence of the lower two levels of the Λ-system results in a population n_3 of the upper level and residual fluorescence is proportional to Γ_{12}, the relaxation rate of this coherence, which also determines the width of the dark resonance. Experimentally, relaxation due to collisions and laser jitter can be made negligible, thus the residual population n_3 as well as the width of the resonance should be determined only by the length of the interaction time. *For this reason*, the lower temperature limit of the VSCPT cooling is said to be unbounded in principle.

Here we show that due to nonlinear processes the "darkness" or ultimate width of the CPT resonance is intrisically limited by a novel type of sidebands in resonance fluorescence, which are present even in the absence of collisions and laser jitter. These single atom processes are caused by four-wave mixing (FWM) processes, which are significant in the near resonant case. Our theoretical analysis gives a simple expression for an additional FWM-contribution to the dephasing rate Γ_{12} of the ground levels, which reads

$$\Gamma_{12}^{\rm FWM} \approx \frac{g_\Lambda^2}{4\omega_{12}^2}\frac{\gamma}{2} \tag{1}$$

and for Cs atom ($^2S_{1/2} \to {}^2P_{3/2}$ transition) at $I \sim 1$ W/cm^2 has a value $\Gamma_{12}^{\rm FWM} \sim 10^4$ s^{-1}, which is large compared to Γ_{12}. At the same time, it is well known that conventional power broadening plays a key role at low and moderate intensities. Therefore the complete dephasing rate reads

$$\left(\Gamma_{12}^{\rm total}\right)^2 = (\Gamma_{12}^{\rm power})^2 + \left(\Gamma_{12}^{\rm FWM}\right)^2 = (\Gamma_{12}^2 + \Gamma_{12}\frac{g_\Lambda^2}{2\gamma}) + \frac{g_\Lambda^4}{64\omega_{12}^4}\gamma^2.$$

Experimentally, the influence of collisions and laser jitter, as well as Doppler broadening, can be made negligible. We therefore can neglect Γ_{12} and, as a result, $\Gamma_{12}^{\rm power}$, but not $\Gamma_{12}^{\rm FWM}$, which dominates at large laser intensity. In other words, we can say that it sets a *fundamental limit* to the dephasing rate of the ground subsystem and thus to the darkness of the CPT-resonance. We discuss also how the FWM processes affect *the refractive index* of the Λ-media.

This work was supported by Volkswagen Stiftung (grant No. 1/72944) and by the Russian Foundation for Basic Research (grant No. 96-03-32867). V. N. Z. also thanks the Alexander von Humboldt foundation for the support.

17:00
WG2

Coherent Four-Wave Mixing for 2D Imaging of Laser-Produced Plasmas

D.A. Akimov, A.B. Fedotov, N.I. Koroteev, A.N. Naumov, D.A. Sidorov-Biryukov, and A.M. Zheltikov
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The development of efficient experimental techniques for the multipoint detection of excited atoms and ions is of considerable importance for combustion and plasma diagnostics [1]. Much attention has been recently focused on one- and two-dimensional imaging techniques based on various schemes of coherent four-wave mixing (FWM), such as coherent anti-Stokes Raman scattering [2] and degenerate four-wave mixing [3].

In this paper, we discuss new applications of two-dimensional mapping based on coherent three-color FWM with hyper-Raman resonances [4] for the investigation of the low-temperature plasma created by laser-induced breakdown. The one-dimensional FWM signal generated in the direction determined by phase matching in a folded FWM scheme [5] is employed to image the spatial distributions of plasma atoms line by line. (Fig. 1).

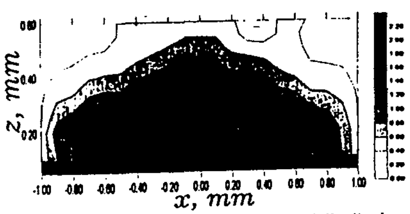

Fig. 1. A two-dimensional map of the spatial distribution of excited lead atoms in a laser-produced plasma

Taking into account distortions of two-dimensional FWM maps of plasma species due to phase mismatch and one-photon absorption [4], we investigate the possibility to extract information concerning the spatial distribution of the populations of excited atomic states from two-dimensional maps of the FWM intensity.

The implemented technique was applied to map the spatial distributions of excited lead and nitrogen atoms in a laser plasma produced on the surface of a lead target in ambient air. To resolve closely spaced and overlapping lines in FWM spectra and to improve the sensitivity of FWM diagnostics, we changed the relative intensities of atomic and ionic lines in broadband FWM spectra by varying polarization vectors of the pumping waves with respect to each other and relative to the axis of the polarization analyzer

This research was made possible in part by Award no. RP1-255 of the US Civilian Research and Development Foundation for the Independent States of the Former Soviet Union (CRDF).

References

1. K. Nyholm, R. Fritzon, and M. Alden, *Appl. Phys. B*, 59, 37 (1994); P. Ewart and M. Kaczmarek, *Appl. Opt.*, 30, 3996 (1991).
2. P.R. Reginer and J.-P. Taran, *Appl. Phys. Lett.* 23, 240 (1973); D.V. Murphy, M.B. Long, R.C. Chang, and A.C. Eckbreth, *Opt. Lett.* 4, 167 (1979).
3. P. Ewart and S.V. O'Leary, *Opt. Lett.*, 11, 279 (1986); P. Ewart, P. Snowdon, and I. Magnusson, *Opt. Lett.* 14, 563 (1989); D.J. Rakestraw, R.L. Farrow, and T. Dreier, *Opt. Lett.* 15, 709 (1990); K. Nyholm, R. Fritzon, and M. Alden, *Opt. Lett.* 18, 1672 (1993).
4. A.B. Fedotov, O.S. Ilyasov, N.I. Koroteev, and A.M. Zheltikov, *Nuovo Cimento D*, 14, 1003 (1992); D.A. Akimov, A.B. Fedotov, N.I. Koroteev, A.N. Naumov, D.A. Sidorov-Biryukov, and A.M. Zheltikov, *Opt. Commun.* 140, 259 (1997).
5. D.A. Akimov, P. Ewart, A.B. Fedotov, N.I. Koroteev, A.N. Naumov, D.A. Sidorov-Biryukov, A.M. Zheltikov, *Laser Physics* 7, 755 (1997).

17:15
WG3

Sensitivity of multimode lasers to intractivity absorption

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Summary

Emission spectra of multimode lasers are very sensitive to selective absorption in the cavity. The sensitivity of measurements of intracavity absorption grows with the laser pulse duration. The ultimate sensitivity obtained with a cw laser is limited by (i) *quantum noise* at a small pump rate, and by (ii) *Rayleigh scattering* or (iii) *nonlinear mode coupling* at a high pump rate. The quantum-limited sensitivity increases with the pump rate. This variation has been demonstrated in multimode diode lasers with external cavity. The equivalent absorption length achieved with this type of laser is about 10 km. The sensitivity of some solid state lasers, e.g. Ti:sapphire laser and rare-earth-doped fiber laser, is limited by *Rayleigh scattering* in the gain material. It depends on the filling factor of the gain material and is independent from the pump rate. The sensitivity for absorption achieved with these lasers corresponds to 100-1000 km of absorption path. The highest spectral sensitivity has been obtained so far with a dye laser. The relative length of the dye jet is very small such that the effect of Rayleigh scattering is stongly suppressed. In this case, the sensitivity to intracavity absorption is limited by a *third-order nonlinearity* such as four-wave mixing due to *population pulsations* or *stimulated Brillouin scattering*. Reduction of nonlinear mode coupling by increasing the cavity length to 3 m, and by decreasing the cavity loss to about 2% per round trip, have resulted in spectral sensitivity to absorption which is equivalent to 70.000 km absorption length, at the pump rate being 1% above the laser threshold. Further enhancement of sensitivity is possible in a strongly dispersive cavity. Identification of particular factors that limit the sensitivity in each type of laser allows one to optimize the laser parameters for most precise, sensitive, and reliable detection of ultra-weak or extremely rarefied absorbers.

17:30
WG4

Impulsive and/or spectral mechanisms associated to ultrashort pulses: phonon excitation and detection

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January 29, 1998

The impulsive term, used for the description of phonon coherent excitation and stimulated scattering by ultra short light pulses, finds its origin in their very short temporal width value compared to the period of the vibrational mode concerned. We present experimental results that are in apparent contradiction with this temporal scheme. They demonstrate the simultaneous existence of various spectral excitation processes. In fact, conflicting behaviors are revealed by the study of polaritons which frequencies are highly sensitive to the excitation field wavevector values.

We will discuss the results performed on polariton E modes in $LiNbO_3$.

The time resolved signal from a Kerr gate pump-probe experiment depends on the contribution or not from a local oscillator. In the first case, there is a splitting of the polariton frequency, that is explained by a CARS-like spectral mechanism. This splitting corresponds to wavevector values deduced from a model that uses two discrete excitation wavelengths and takes into account dispersion in the refractive indices. In the second case, only one frequency is measured, in concordance with the impulsive picture.

17:45
WG5

FOUR-WAVE SCATTERING BY COHERENTLY EXCITED POLARITONS

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The four-wave scattering by coherently excited phonon polaritons is the cascade part of the four-wave coherent scattering in non-centrosymmetrical media. We studied the intensity of the Stokes component as a function of phase mismatches. In our experiments we used $LiIO_3$, single-domain crystals of $Mg{:}LiNbO_3$ and $Nd{:}Mg{:}LiNbO_3$, and periodically poled $Nd{:}Mg{:}LiNbO_3$ crystals. Pumping waves with the frequencies ω_1 and ω_2, located in the near IR region, excited the polariton with the frequency $\omega_p=\omega_1-\omega_2$, the third wave with the frequency ω_L, located in the visible region, was scattered by the driven polariton. The intensity of the scattered radiation I_s was measured under different values of the phase mismatches τ_1 and τ_2 corresponding to the first and the second stages of the process.

According to the conventional model [1], polariton dispersion law can be completely obtained from the dependence of I_s on the single variable τ_1. One can obtain $I_s(\tau_1)$ from $I_s(\tau_1, \tau_2)$ intersecting it by the surface given by the phase-matching condition for the direct four-wave interaction: $k_L-k_s=k_1-k_2$. We determined the real part of the polariton wavevector $k_p'(\omega_p)$ measuring the position of the maximum of $I_s(\tau_1)$, and the imaginary part $k_p''(\omega_p)$ from its halfwidth. All results obtained for $LiIO_3$ and results on $k_p'(\omega_p)$ for doped $LiNbO_3$ are in a good agreement with the data of the near-forward Raman scattering [2]. But measurements of $k_p''(\omega_p)$ for all doped $LiNbO_3$ showed a discrepancy of more than an order. The influence of the photorefractive properties of $LiNbO_3$ is considered in order to explain that effect.

1. G.Kh.Kitaeva, A.A.Mikhailovsky et al. Opt.Comm., **138**,p. 242, 1997.
2. G.Kh.Kitaeva, A.A.Mikhailovsky et al. Appl.Phys.B, *66*, p.201, 1998.

18:00
WG6

DISCRETENESS AND LOCAL FIELD EFFECTS IN CLASSICAL MOLECULAR OPTICS

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The talk is devoted to the study of the connection of the macroscopic optical properties of the medium with its microstructure, i.e., geometric disposition of the elementary radiators and the distances b between them. First, steming from the supposition that certain new quantities constructed from the local field, polarization vector, *electric-quadrupole and magnetic-dipole volume densities, and their gradients must* satisfy both integral and wave equations, we apply well known in classical molecular optics the method of integral equations (MIE) for arbitrary nonlinear and anisotropic medium for three-dimentional (Phys.Rev.A,49, 1313 (1994)) and two-dimentional (Phys.Rev.A,50, 714 (1994)) cases. Only unitless geometric tensor of a lattice and the radiator's polarizability tensor, but not a lattice grain size b, determine the local field factor and enter into the anisotropic analogues of the Lorentz-Lotenz formula. A connection between the microscopic and macroscopic characteristics was established. Second, we generalized MIE (GMIE) to the case of a discrete weakly rarefied madium ($b/\lambda << 1$, where λ is the light wavelength) (Phys.Rev.E,56, 6123 (1997)). Although just a discreteness gives rise to the local field effects "incorporated" into the Lorentz-Lorenz formula and anisotropic analogues, these formulas reveal only the presence of the medium's discreteness, but not its "magnitude" b. We pursue a line of thought by Mandelstam, who first demonstrated that effects of the effective amplification due to the propagation delay in the interaction of the radiators and the radiation damping effects for the regular isotropic mediumare exactly balanced against each other (Mandelstam cancellation). We prove this for any nonlinear and anisotropic regular medium. The general form of Extinction Theorem is found. The validity of Maxwell Equations is proved with the accuracy up to the third order of parameter b/λ. The developed approach enabled us to calculate the local fields factors and the dielectric permittivity of a rarefied medium. An essential quantitative and *qualitative distinction between the gaslike, jellylike and cubic lattice media,* customarily treated as optically isotropic, was revealed. Our results may be applied to calculation of the optical properties of some specific types of media, such as a cooled atomic gas, multicomponent composite materials, and quantum dot structures.

18:15
WG7

INTRACAVITY INTERACTION OF SHORT PULSE FREQUENCY SELECTIVE CO LASER RADIATION WITH VIBRATIONALLY EXCITED ACTIVE MEDIUM

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The original method of vibrational kinetics investigation using restoration of population distribution function in excited active medium of pulsed e-beam controlled discharge CO laser after its fast selective disturbance is presented. On the base of theoretically defined parameters (selected vibrational band $V \rightarrow V-1$ from $5 \rightarrow 4$ up to $17 \rightarrow 16$, active medium density of 0.05 Amagat, time delay between the first (disturbing) and the second (probe) laser pulses from 1 up to 8 μs) we experimentally realized the frequency selective mode of e-beam controlled discharge double pulse Q-switched CO laser operation.

The analysis of our experimental data on second laser pulse energy restoration with respect to the first's one depending on time delay between two short ($\tau_{0.1} \sim 1\mu s$) laser pulses (and, respectively, on restoration of population distribution function after its fast selective disturbance) demonstrated that the use of classical model of VV exchange in theoretical calculations give the satisfactory agreement with the experiments only for low vibrational-rotational transitions ($V<14-15$) of CO molecule.

It was shown that for the more exact description of vibrational energy exchange kinetics on highly located levels of CO molecule (to get more precise information on rate constants of VV exchange) it appeared to be necessary to take into account multi-quantum processes which are not taken into account in classical model of VV exchange.

16:45-18:30 **RED HALL**

WH - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures II

Presider: *V.I. Emel'yanov, M.V.Lomonosov Moscow State Univ., Russia*

16:45
WH1
(Invited)

Ultrafast modulation of 1.55 μm QW laser structures: optically detected carrier dynamics, limiting mechanisms and applications

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Carrier dynamics are of considerable importance to achieve large bandwidths under high frequency modulation of optoelectronic devices such as semiconductor lasers, modulators and amplifiers. For direct modulation of laser devices the temporal variation in the injection current carries the bit information to be translated into an intensity variation of the laser emission. To obtain highest bit rates the laser should translate the current transients as fast and precisely as possible into corresponding light intensity transients requiring an efficient and ultrafast carrier transfer from the contacts to the laseractive quantum wells (QWs). This paper outlines the different retardation effects of the carrier transfer such as: carrier transport in the confinement layers, carrier capture into the QWs, carrier tunneling between the individual wells, and thermionic emission of the carriers out of the wells. Using specific high resolution time-of-flight studies the dominating retardation effects are separated and studied experimentally and theoretically by corresponding model calculations. A comparison of different material systems shows that GaInAsP is beneficial due to considerable advantages in technological implementation processes and AlGaInAs is superior from a physical point of view enabling higher band-widths due to larger conduction band discontinuities. The equalization of the carrier densities in the individual wells is found to be mainly retarded by hole thermionic emission. Hole transport in the p-sided confinement layer and electron capture from the p-sided confinement layer is also found to be also a limiting factor. These results are used to optimize AlGaInAs/InP lasers with asymmetric confinement layers. The p-sided confinement layer is reduced on the costs of the n-sided confinement layer to obtain (i) a faster hole transport across the p-sided confinement layer and (ii) to accelerate the capture of electrons from the p-sided confinement layers beeing uncaptured during the transfer across the QWs. In the experiment a modulation bandwidth of 26GHz is obtained. Even higher values are found in corresponding theoretical model calculations demonstrating an interesting development potential.

17:15
WH2
(Invited)

Nonlinear Photoluminescence from a Normal-Mode-Coupling Semiconductor Microcavity

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Recently there has been much interest in the photoluminescence (PL) properties of semiconducto microcavities that exhibit normal-mode coupling (NMC). [1] When a narrow-linewidth quantum well is grow inside a moderately high-finesse microcavity, the exciton-photon coupling results in two peaks in transmission whe the cavity resonance and the exciton resonance coincide. When the cavity resonance is detuned above the excito resonance energy and the microcavity is pumped above the mirror stopband, the PL exhibits a curious threshold-lik behavior: as the carrier density is increased, the upper-branch PL increases rapidly while the lower-branch PL tend to saturate. This behavior was attributed to the spontaneous buildup of exciton polariton population in microcavity, i.e., an exciton polariton laser or boser [2], based on final-state stimulation to a Bose condensate. Th hope was that exciton polariton lasing would provide a source of coherent radiation with a threshold well below th lasing threshold. We performed both cw and fs experiments [3] over a wide range of excitations from very lov densities to above lasing threshold, not only reproducing the main features of the earlier data but also determinin that the carrier density is too high for the "boser action" to be bosonic. Simultaneous measurements of nonlinear cv transmission and PL spectra showed that as the upper PL intensity overtakes the lower, the transmission become single-peaked. This indicates that the density at crossover is so high that the exciton absorption is largely gone causing the two transmission peaks in the NMC regime to collapse to a single peak. The NMC splitting (generalize Rabi frequency at low excitations) has already decreased to the detuning by the crossover density. In fact, lasin finally occurs very close to the frequency of the upper-peak emission at crossover. Another indicator of high densit is the fact that the crossover density is less than a factor of two below the lasing-threshold density. Pulsed Pl spectra, as used in [2], are still double-peaked almost all the way to lasing, but this is a fluke of the pulse measurements which average over all cw spectra of lower density [4]. Spatial averaging [4], which can also obscur the data like temporal averaging, was avoided in [3-5] by aperturing. The experimental data show that the collaps of NMC to the weak coupling regime occurs right in the middle of the "boser action" regime, so that it cannot be th result of Bose condensation. A fully quantum microscopic theory [3] has been developed which explains all of th data as fermions cooling and photoluminescing in a microcavity. Since this theory treats electrons and holes as th fermions they are, it can be used to compute the bosonic commutator, which should be unity if the system can b described bosonically. The value of this commutator has already dropped to roughly 0.5 by crossover, agai indicating the too-high-density nonbosonic character. The authors of [2] retract their "exciton polariton laser interpretation of their _boser action_ data in [5], but do not retract the theoretical possibility. Support i acknowledged in Tucson by AFOSR, COEDIP, DARPA/ARO, JSOP, and NSF and in Marburg by the DFG, th Leibniz prize, a Heisenberg (F.J.) and an EC fellowship (M.K.).

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[1] C. Weisbuch, M. Nishioka, A. Ishikawa, and Y. Arakawa, Phys. Rev. Lett. 69, 3314 (1992).
[2] S. Pau, H. Cao, J. Jacobson, G. Bjvrk, Y. Yamamoto, A. Imamoglu, Phys. Rev. A 54, R1789 (1996).
[3] M. Kira, F. Jahnke, S. W. Koch, J. D. Berger, D. V. Wick, G. Khitrova, and H. M. Gibbs, Phys. Rev. Lett. 79, 5170 (1997). See also F. Jahnke et al., Phys. Rev. Lett. 77, 5257 (1996).
[4] X. Fan, H. Wang, H. Q. Hou, and B. E. Hammons, Phys. Rev. A, to be published (1997).
[5] H. Cao, S. Pau, J. M. Jacobson, G. Bjvrk, Y. Yamamoto, and Imamoglu, Phys. Rev. A 55, 4632 (1997).

17:45
WH3
(Invited)

THREE-DIMENSIONAL PHOTONIC CRYSTALS EXHIBITING PHOTONIC PSEUDOGAP IN THE VISIBLE RANGE

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Photon density of states can be engineered similarly to electron density of states in bulk solids and quantum size structures. There are two potential ways to modify significantly the density of photon states with respect to a free space. One is to use microcavities. Another one is to create a medium in which density of photon states is modified because of the modulated dielectric constant. In the case of strong modulation in the three-dimensional space the omnidirectional forbidden gap develops similar to the electron bandgap in semiconductors. Such a structure usually referred to as a "photonic crystal" has been proposed a decade ago. In spite of the significant progress in the theory, practical realization of a three-dimensional lattice with the desirable periodic structure in the submicron range has met a serious problem.

We review the results of synthesis and optical studies of solid-state three-dimensional dielectric lattices based on self-organized colloidal crystals. Specifically, silica based face-centered cubic lattices have been developed and examined[1]. A formation of photonic pseudo-gap resulting in a wide stop-band in the visible range has been analyzed. Pseudo-gap dependence on the refractive index modulation which can be achieved by impregnation of the cavities with highly refractive fillers was studied. SiO_2 /TiO_2 ans SiO_2/Fe_2O_3-lattices have been obtained by means of sol-gel reactions. Impregnation of lattices with resonantly absorbing and emitting species like dye molecules, rare-earth ions and semiconductor quantum dots and a number of applications based on interplay of electronic and morphological resonanses are considered.

1. V. N. Bogomolov, S.V. Gaponenko et al. Phys. Rev. E 55, 7619-7625 (1997).

18:15
WH4
(Invited)

Micro-sized active optical multi-channel switching in photonic crystals

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Department of Physics, Hong Kong Baptist University, Hong Kong

The photonic band gap structure is a man-made crystal in which the index of refraction varies periodically in three dimensions. In photonic crystals there are certain frequency regions (band gaps) and the electro-magnetic (E-M) field with frequencies within the regions could not propagate.The locations and sizes of the gaps are determined by the indices of refraction and the structure of the photonic crystals. The photonic crystals have great potential in many applications such as communication and micro-optical devices, due to the ability to control the propagation of the light. One of the applications is optical switch. Our study shows that the spontaneous emission field from a two-level atom in the photonic crystals is composed of two parts, 1. a localized field, which always exists, and 2. one or two propagating modes. The emission of the propagating mode depends on the gap size and the relative position of the upper-level of the atom with respect to the edges of the two bands. The propagating modes have a sudden jump from zero to a certain value when the gap or the related position of the upper level changes. This jump can be used to design an active optical two-channel or four-channel switch. Due to the localized field being within a few dozen atoms, the switch can be designed based on the crystal's structure of the primitive cell. This kind switch might be useful in optical computer.

16:45-18:30 **BEIGE HALL**

WI - High Precision Measurements in Optics II

Presider: *V.I. Denisov, Inst., of Laser Physics, Russia*

16:45
WI1
(Invited)

Optical frequency standards based on dispersion methane lines and its applications for precise measurements

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Optical frequency standards based on double-mode gas (He-Ne) and solid-state (RbCl:Li) lasers stabilised over supernarrow resonances of saturated dispersion of lines in ν_3 vibr.-rot. methane band (λ=3.2-3.4 μm) are prospective for achieving the reproducibility and accuracy of 10^{-14}- 10^{-15} level. These values are comparable with the present and near future parameters of the Cs frequency standard. Today the role of He-Ne/CH4 standards has been increased due to creation of transportable systems (with the resolved magnetic hyperfine structure) suitable for frequency calibration of the sources of optical without realising full-scale radio-optical frequency chains. Its carrier frequency ω=88THz (λ=3.39 μm), measured with the uncertainty ~10^{-13} at one of the existing radio-optical chains can be transferred to any laboratory with the same level of accuracy. Frequency synthesis in the range 10^{14}- 10^{15} Hz is much less complicated problem as compared to the synthesis in the range 10^{11}- 10^{14} Hz.

The recent paper gives the results of investigations of the methane dispersion resonances line shape (relative width 10^{-11}- 10^{-12}) taking into account a number of physics and methodical factors. Special attention is paid to the results of frequency calibration of the transportable He-Ne/CH4 OFS (developed in the Lebedev Institute) in the units of the Cs/H-maser primary standard using the radio-optical frequency chain of Physikalisch - Technische Bundesanstalt (PTB, Germany) on 1993-1997. Comparison of the calibrated transportable systems with the stationary ones (recoil doublet resolved) at the Lebedev Institute allowed to determine the frequency of unperturbed transition of the $F_2^{(2)}$ methane line with the uncertainty $5*10^{-13}$.

Next development of the methane OFS is possible via usage the transitions from the lower rotational levels. Thermal cooling (down 77K...40K) of *a methane cell leads to* 10^2-10^3 times increasing of the absorption coefficient. In combination with detection of slow molecules it allows to realise a compact transportable CH4 OFS with reproducibility and accuracy ~10^{-15} . First experiments with a RbCl:Li color-center laser, optically pumped by a powerful laser diode instead of bulky and noisy Kr^+ laser were performed.

17:15
WI2
(Invited)

Paper is not available

17:45
WI3
(Invited)

Fast modulation of FIR radiation

A. Bertolini ,N. Beverini, G. Carelli, N. Ioli, C.A. Massa, A. Moretti and F. Strumia
Dipartimento di Fisica, CNR and INFM

The Ca atomic frequency standard can be described in this way:
- Production of a thermic Ca atomic beam.- Laser cooling on the fundamental level with the 1S0 - 1P1 transition at 422.7 nm.- Optical excitation to the metastable 3P1 level with the red line at 657.2 nm.
- Fluorescence detection on the natural decay 3P1 - 1S0 of the 1.56 THz resonance induced on the 3P1 - 3P0 fine structure transition, that constitutes the clock transition. About the last point an optically pumped FIR molecular lasers is a good candidate for the interrogation system, given its excellent characteristics of monochromaticity, linewidth and stability, but the coincidence of the frequencies of the atomic transition and of the laser molecular transition is needed. Up to now the closest laser lines to transitions of metrological interest for calcium are 300~MHz apart. A possible way to bypass this problem is to generate sidebands with some non linear devices, in this work we propose to modulate the reflectivity of a semiconductor to generate tunable FIR radiation. InSb is a III-V semiconductor showing a minimum of reflectivity in the FIR region due to absorption at the plasma resonance, related to the electron density in the conduction band, whose position is greatly dependent on temperature. Sending a FIR radiation on a InSb crystal and switching by repeated photoionizations the reflectivity of the semiconductor, a radiation can be obtained with the same shape of the ionizing source. For every FIR wavelength, changing the semiconductor temperature, we can set the work point near to the reflectivity minimum and hence we can estimate and get an high change of reflectivity. We used InSb to make a pulses generator for FIR radiation

In our experiment we inject electrons, by photoionization, in the conduction band of an InSb crystal, kept at a temperature close to the reflectivity minimum, and hence we change its reflectivity at the FIR wavelength. The ionizing radiation is produced by a pulsed 1.06 um Nd-YAG laser, whose photon energy (1.2 eV) is greater than the energy gap of InSb (0.18 eV). From a preliminary work for a 1 mm thick crystal with 20 ns Nd-YAG pulses a power of 50 uJ is needed. It must be remarked the high degree of monochromaticity of the FIR pulse, so that the linewidth of the fast FIR pulse is close to the Fourier-transform limit. The reflected FIR pulses have about the same temporal width of the pulses of the ionizing laser. This means that diffusion and recombination are fast enough to make the reflectivity follow the instantaneous intensity of the incident radiation, at least for the time scale of our Nd-YAG laser. The Nd-YAG power necessary to change the reflectivity up to the maximum depends on the temperature of the sample, for this reason for the lines at shorter wavelengths, whose plasma transition is at higher temperatures, much more power is needed than for longer ones. As a matter of fact changing the working point from 210 K to 320 K means a change in the initial charge density of the crystal from 8.10^{14} to 2.10^{16} cm^{-3}, and then a larger charge injection is required to get the same effect. The samples are InSb slices 10 x 10 x 1 mm with face orientation (111) and a carrier density of 10^{14} cm^{-3} at 77 K. The source of FIR radiation is a waveguide molecular laser, optically pumped by a CW CO_2 laser. The samples are hold in a helium gas flow cryostat working between 300~K and 20~K. An InSb slice was thinned to 0.025~mm; for this sample the Nd-YAG pulse energy necessary to reach the maximum of reflectivity is 50 uJ for a FIR radiation at 119um. For the same line a relative reflectivity variation of 10% is obtained with a pulse energy of only 1 uJ. We are now trying a new Nd-YAG laser oscillator giving pulses with an energy of 300 nJ, a time duration of about 100 ps, and a repetition rate up to 100~MHz. In this configuration it should be possible to generate a sideband. A modulated generator using a less powerful ionizing source than Nd-YAG laser like a diode laser can become practicable using InSb films. We tried some samples on MgO substrate, we could obtain some pulses but up to now they show a behavior quite far from that of the crystal for the poor christallografic quality of the deposition, better substrate are expected to grow epitaxial films.

18:15
WI4

Laser gravitational wave detectors of high precision

S.N. Bagayev, E.V. Baklanov, V.I. Denisov, I.I. Korel, P.V. Pokasov

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We consider the recent results on creation of ultra-stable (10^{-15} - 10^{-16}) lasers of new generation and amplified optical bistability are directed to the modernisation of experiments on detection of gravitational waves. There are presented principal schemes of highly senitive laser detectors of gravitational waves against periodic astrophysical objects such as: 1.6 ms pulsar PSR 1937+21 with expected gravitational wave amplitude $h \le 7\times10^{-27}$, 2.1 ms pulsar in SN 1987A ($h \le 1.4\times10^{-26}$), PSR J0437-4715 ($h \le 3\times10^{-26}$ at 346 Hz), using highly stable laser radiation. Using of amplified optical bistability in heterodyne method of registration of small displacements of the resonant gravitational antenna (elastic rod) make it possible to increase the signal-noise ratio up to the 10^4 - 10^5.

We also consider the possibility of integrating of resonance gravitational antenna in other existing projects of registration of gravitational waves in space and using long baseline laser interferometers.

Using of the new type of amplified optical bistability for amplifying of weak components induced by the gravitational wave also for registration of the phase deviation in resonant gravitational antennas and long baseline laser interferometers (LIGO, VIRGO, GEO etc.) is to be studied. Increasing of the laser power (in 10^4 times) in experiments with long baseline laser interferometers will reduce the registration threshold of the interferometer in 10^2 times.

This work was supported by the Russian Foundation for Basic Research (project № 96-02-19498).

16:45-18:30 **PRESIDENT'S HALL**

WJ-Basic Concepts of Laser Chemistry, Biophysics and Biomedicine II

Presider: *V.N. Bagratashvili, Sci. Research Ctr. For Technol. Lasers, Russia*

16:45 WJ1 (Invited)

Can a mechanism based on changes in redox properties of cytochrome c oxidase be crucial in explaining of low-power laser effects?

Tiina Karu
Laser Technology Research Center of Russian Acad. Sci., Troitsk, Moscow Region, Russian Federation

Low-power laser therapy is a phototherapeutic method promoted within the last two decades as an effective tool for the treatment of soft tissue injuries, pain, arthritis and other conditions. The mechanism of stimulating action of monochromatic light in red-to-near IR region is not established neither on organism nor on cellular level.

An analysis of various action spectra (dependences of biological responses on the wavelength used for irradiation) indicates that the terminal oxidase of the respiratory chain in eukaryotic cells, cytochrome c oxidase, is the photoacceptor molecule for red-to-near IR laser radiation. It is suggested that the photoacceptor is not the fully reduced or oxidized enzyme, but one of its intermediate forms (a so-called mixed valence oxidase) which had not yet been identified.

At least four types of reactions occur with the participation of the photoacceptor molecule after its electronic excitation: changes in its redox properties and acceleration *of electronic transfer*, one-electron auto-oxidation ($O_2^{\bullet-}$ formation), photodynamic action ($^1O_2$ formation), and changes in biochemical activity induced by the local transient heating of the absorbing chromophores. The *question is which* mechanism is responsible for the specific cellular responses under study (reactions connected with an increase of proliferation). The experimental measurements of redox absorbance changes in living cells under irradiation with a semiconductor laser at 670 or 820 nm indicate that changes in redox properties of absorbing chromophores (Cu_A and Cu_B) in the molecule of cytochrome c oxidase might have a great importance to explain the mechanisms of low-power laser effects (effects connected with low-power laser therapy). Results of comparison of the absorption spectra of the HeLa cells and various action spectra concerning the same cells allows one to conclude that both absorption and action spectra have similar bands at 670-680 and 770-780 nm. These bands belong supposedly to chromophore Cu_B in the oxidized state and Cu_B in the reduced state. It was found that the irradiation at both wavelengths (670 and 820 nm) caused an increase in absorption band at 670-680 nm and a decrease in absorption band at 770-780 nm, the kinetics of the processes being different for 680 and 820 nm irradiation. Quite possible that the first experimental results of measurements of redox absorbance changes in living cells indicate that the mechanism based on changes in redox properties of cytochrome c oxidase might be crucial in explaining of low-power laser effects.

17:15 WJ2 (Invited)

Laser time-resolved optical spectroscopy of cytochrome c oxidase

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Cytochrome c oxidase (COX) is a terminal component of most respiratory chains. It catalyses the four electron stepwise reduction of molecular oxygen to water via the oxidation of cytochrome c. This enzymatic reaction is linked to a transport of proton across the inner mithochondrial membrane.

In this paper we present the results of picosecond and nanosecond optical spectroscopy studies of photophysics and photochemistry of COX prepared from bovine heart.

1. Picosecond absorption spectroscopy has been applied to measure the transient spectra and excited state lifetimes for five different derivatives of COX: fully reduced and oxidized *forms, their complexes with* CN^-, and *one-electron reduced form. In* all the investigated compounds we have observed complicated time evolution of transient spectral changes. It has been possible to separate out the process linked with the biexponential *heme cooling.* The fast part of this process coincides in time with the heme electronic relaxation. The orbital nature of excited states of heme a and heme a_3 and the mechanism and dynamics of electron transfer and ligand dissociation and shuttle will be discussed.
2. Nanosecond absorption kinetic spectroscopy has been used to study the photoinduced reduction of one-electron reduced COX and the reverse oxidation. The multicomponent kinetics of the reoxidation has been found. The slowest component of this reaction is of millisecond duration. The mechanism of this redox reaction is proposed.

16:45-18:15 **BLUE HALL**

WK - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics II

Presider: *N.B. Delone, General Physics Inst., Russia*

16:45 WK1

Generation of Coherent X-ray Radiation by Atoms in Superstrong Laser Fields: Fundamental Restrictions, Optimizations and Ultimate Possibilities

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A semiclassical approach is developed to investigate tunnel above-threshold ionization (TATI) of atoms and generation of short-wavelength radiation (GSWR) which takes into account all essential strong-field effects. It enables to study fundamental restrictions on break-through to coherent X-ray range by this method. As atomic state depletion impose the main restriction, it has been described exactly based on numerical solution of the Schrödinger equation in static limit. This solution demonstrates an essential decrease of ionization rate growth in superstrong laser fields. To diminish the depletion effect, ultrashort (a few optical periods) and superintense laser pulses should be used for pumping. In this case considerable restrictions on coherent X-ray generation arise due to relativistic effects: longitudinal drift of ionized electron in the continuum leads to electron missing a parent ion. It causes a superior limit for the increase of maximum (cut-off) frequency $\Omega \sim 10^3$ eV of recombination radiation would-be generated. The influence of the Coulomb potential of the parent ion and the relativistic effects on ionized electron motion in the continuum were investigated for variety laser parameters including laser fields of complex configurations (two-colour fields, fields with different polarizations, etc.). A number of new features of TATI are predicted by these investigations as well as a possibility of GSWR optimization. For example, in two-colour fields there is a possibility to enhance the number of recombined photoelectrons and to increase their kinetic energies which leads to the increase of GSWR intensity as well as GSWR cut-off frequency. Also, a limit for GSWR efficiency has been determined at the growth of gas or plasma density N. This limit takes place when ionized electron misses the parent ion due to disturbing of its motion by neighbour ions. Optimal density N_o strongly depends on laser wavelength λ ($N_{o\ min} \sim \lambda^{-12/5}$) and decreases with the increase of GSWR frequency (that is in accordance with the recent measurements).

17:00 WK2

POLARIZATION EFFECTS IN RELATIVISTIC PHOTOIONIZATION

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Summary

Short-pulse, high-intensity laser experiments are now being done in a domain where intensity-induced relativistic effects occur. The SFA (Strong-Field Approximation) is a theoretical method specially suited to relativistic problems since the only approximation in the method relies upon the dominance of the laser field over the Coulomb field in governing the behavior of the ionized electron. This condition is satisfied with circular polarization [1] even before the threshold for relativistic conditions is reached. Linear polarization of the laser is more difficult for the SFA in that rescattering by the remnant ion is neglected in the lowest-order form of the theory (although revisiting is included). However, relativistic conditions can be shown to reduce the importance of rescattering, and the SFA approaches completeness as the intensity rises. We show on qualitative grounds that the dipole approximation fails with linear polarization at a surprisingly early stage. Our SFA calculations, now available for both linear and circular polarization, exhibit the effects of this early onset. Our theory is formulated for treatment of the ionization of hydrogen. Dirac methods are used throughout. This theoretical foundation makes possible, in principle, extensions to all atoms and all laser pulse intensity profiles by extending methods developed for the non-relativistic problem. Among the relativistic effects we find are the forward shift of the electron spectrum due to the momentum of the absorbed photons, and alterations of the stabilization phenomenon [1].

[1] H. R. Reiss, "Energetic electrons in strong-field ionization", *Phys. Rev. A* 54(3), R1765-R1768 (1996); D. P. Crawford and H. R. Reiss, "Stabilization in relativistic photoionization with circularly polarized light", *Phys. Rev. A* 50(2), 1844-1850 (1994).

17:30
WK3

HOT PHOTOELECTRON PLATEAU IN THE TUNNELING AND THE CORE FORMFACTOR

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The angle-resolved photoelectron spectra including the high energy plateau have been measured in the tunneling regime [1]. A good fit to the data has been achieved with the semiclassical model accounting for the scattering phase shifts from both the Coulomb and *short range ion potentials. The observed plateau exhibits a smooth* decline in distinction from quantum calculations for a model zero-range potential [2].

We report on the high energy spectrum in the tunneling regime derived within quantum approach accounting for the scattering of the ionized wave packet [3] by the residual ion with a multielectron core. Even at most simplified distribution of electrons backscattered by the ion after the first return and detected with the energy $\varepsilon = p^2/2$ along the direction of linear polarization describes many features of the spectrum

$$\frac{dw}{d^3p} \propto \frac{\omega^5}{F^3} V^2(p) \exp\left(-\frac{2F_a}{3F(\varphi_0)}\right) \qquad (1)$$

Here the field phase at the time of ionization φ_0 depends on the scaled variable $x = \varepsilon / 10U_p \le 1$. The factor p^{-2} from the ion potential $V(p) = 4\pi Z_{eff}(p)/p^2$ contributes to the decline of the plateau. Due to the effective charge $Z_{eff}(p) \ge Z_i$ ions with a core scatter electrons more efficiently than a pure Coulomb field with the net ion charge Z_i. As well Eq. (1) predicts an overall decrease of the plateau at high laser intensities and its strong dependence on the laser frequency.

References.

1. Sheehy B. *at al.*, in *Multiphoton Processes* 1996, (IPCS No.154), p. 106
2. Lohr A., Kleber M., Kopold R. and Becker W., 1997, *Phys. Rev.*, A 55, R4003
3. Goreslavskii S.P., Popruzhenko S.V. , 1997, *Laser Phys.*, (in press)

17:45
WK4

STRONG-FIELD IONIZATION DYNAMICS AND KRAMERS-HENNEBERGER APPROXIMATION

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Kramers - Henneberger (KH) method is widely used to investigate the ionization and stabilization of atoms and negative ions in super-strong high frequency fields. This method is based on the Kramers transformation and studying of the system evolution in the frame of reference, oscillating as a free electron in the electromagnetic field, and in terms of KH stationary states.

The aim of this report is to analyze which states (KH or atomic) are preferable from physical point of view to describe the system "atom + electromagnetic wave field". For this goal the method of the direct numerical solution of the non-stationary Schroedinger equation was employed. The results of these simulations obtained for short-range potential were analyzed both in laboratory and Kramers frame. It was found that under definite conditions the system "atom + external electromagnetic wave field" demonstrates the features (energy levels, stationary state wave functions) of the KH potential:

1. It was found that there is the correlation between KH stationary states population during the laser pulse action and the probability to find the system in the bound atomic state after the laser pulse is over.
2. The photoelectron energy spectra were obtained. The peak positions in these spectra are shown to correspond to the ionization from the stationary KH states.
3. The real existance of the KH potential was also confirmed in two-color numerical experiments. In these experiments high-frequency strong electromagnetic field was used to create the KH potential and the second field of quite low intensity was used to study transtions between different bound states of the KH potential.

The phenomenon of atomic stabilization is studied and its connection with the KH description is discussed.

18:00
WK5

ATOMIC ANTENNA IN MULTIPLE IONIZATION

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A review of an idea of the "atomic antenna" first suggested in [1] and developed recently in [2,3] is given. Consider multiphoton many-electron processes when an atom is placed in a laser field. Suppose that first single-electron multiphoton ionization takes place. Then in the vicinity of the atom there appears the ionized electron which is bound by atomic forces no more. it can propagate freely, and therefore strongly interacts with the external field. This interaction results in the wiggling of the ionized electron which can make its kinetic energy be high in some moments of time. There is a possibility that the ionized electron returns to the parent atom and transfers the absorbed energy to it [1]. This can result in a number of phenomena including multiple ionization, ionization with excitation, high harmonic generation. The wiggling energy can also be transfered into excitation of high ATI levels. The described mechanism makes all these phenomena much more probable then the direct absorption. The first ionized electron for these processes plays a role similar to antenna in conventional radio devices.

It is important that the process of the single-electron ionization requires that the ionized electron goes under the potential barriera long way out from the atom. It emerges from under the barrier, roughly speaking when the potential of the external field becomes comparable with the atomic potential. This can happen in two points up and down the field. This picture of the single-electron process follows from the Keldysh approach [4], which a recent modification have made quantitatively reliable [5]. The firstly ionized electron appears from under the potential barrier at the points, starting from which the electron wave function propagates in all directions creating the complicates pattern in the angular distribution for the single-elctron process [5]. This fact is also very important for many-electron processes. The possibility for the firstly ionized electron to propagate in *any* direction from some points separated from the atom allows the return of the ionized electon to the parent atomic particle. This fact ensures that the atomic antenna mechanism works for *any* field strength. For strong field the wiggling energy can be high enough to put he mechanism in action by itself. For weaker fields the ATI states of the firstly ionized electron become important [2,3].

[1] M.Yu.Kuchiev, *Sov.Phys.JETP* **45**, 404 (1987).
[2] M.Yu.Kuchiev, *J.Phys.B:At.Mol.Opt.Phys.* **28**, 5093 (1995);
[3] M.Yu.Kuchiev, *Phys.Lett.A* **21277**, (1996).
[4] L.V.Keldysh *Sov. Phys.-JETP* **20**, 1307 (1965).
[5] G.F.Gribakin and M.Yu.Kuchiev, *Phys. Rev. A* **55**, 3760 (1977); *J. Phys. B* **30**, L657 (1997).

Poster Session

18:30-20:00 **GREEN HALL**

WL - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics

WL1

THE INFLUENCE OF MOTIONAL NARROWING ON THE MEASURABILITY OF HYDROGEN CONCENTRATION BY COHERENT ANTI-STOKES RAMAN SPECTROSCOPY

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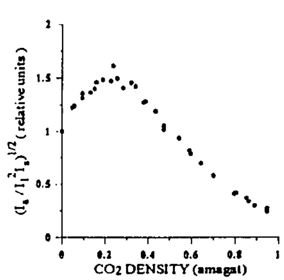
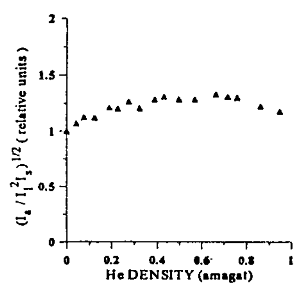
This study was made of measurement of hydrogen concentration in gas mixtures by Coherent anti-Stokes Raman Spectroscopy (CARS) with the aim of devising a technique for the detection of hydrogen released from metals and insulating liquids exposed to a variety of external agencies.

The CARS method requires biharmonic laser pumping (BLP). The method of Stimulated Raman Scattering in the vibrational $Q_{01}(1)$ line of hydrogen molecules at 0.27 GPa pressure ($T = 285\ K$) was used to get BLP.

We have investigated the CARS signal $(I_a/I_l^2 I_s)^{1/2}$, which appeared in the measuring chamber containing hydrogen of constant density of 0.001 amagat, depending on the density ρ of buffer gas (CO_2, He) in the same chamber (Figs), here I_a - intensity of an anti-Stokes wave; I_l, I_s are, respectively, intensities of the laser pump and Stokes components of BLP with the frequencies ω_l and ω_s. $\Omega \approx (\omega_l - \omega_s)$ is the frequency of Raman-active $Q_{01}(1)$ transition of H_2.





The dependencies of $(I_a/I_l^2 I_s)^{1/2}(\rho)$ shown in Figs are due to motional narrowing and

WL2

SELECTIVE SATURATION OF ABSORPTION LINES OF AGGREGATE NEODIMIUM CENTERS IN CaF_2 CRYSTAL

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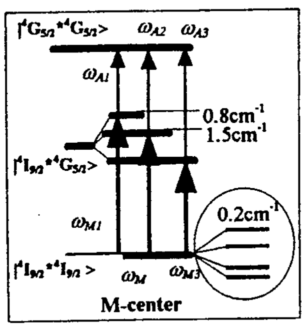
The spectral structure of N(quartet) and M(pair)-centers of Nd ions in a CaF_2 crystals is investigated by frequency-selective laser saturation and ns time resolved pump/probe spectroscopy. We used the radiation of two tunable dye lasers with a pulse duration of 5 ns and a linewidth of 0.2-0.07cm^{-1}. We performed experiments for various pump-probe time delays (0-22ns) and sample temperatures (8-30K). It was shown that the absorption spectrum of M and N centers reflect the splitting of lowest $^4G_{5/2}$ Stark level due to a strong coherent interaction between the Nd ions in clusters with total splitting values 2.3 and 3.3 cm^{-1} for M and N centers, respectively. The pump-induced absorption change for the M-center exhibits a pronounced anti-hole whose position depends on the excitation wavelength. The antihole corresponds to an absorption of the second Nd ion in the singly excited ion pair ($|^4I_{9/2},{}^2G_{5/2}\rangle \rightarrow |^4G_{5/2},{}^4G_{5/2}\rangle$). An electronic energy level diagram, including singly and doubly excited states for the strongly interacting pair can be deduced from the measurements. The dynamics of the saturation absorption spectra for different time delays between probe/pump pulses allowed us to estimate the relaxation time among ground and excited state sublevels (~10 ns). This time is consistent with the results obtained by the accumulated photon echo technique. For N the centers complicated absorption saturation dynamics are observed, which is explained by a significant absorption of singly excited centers (N*) from a metastable level ($|3(^4I_{9/2}),{}^4F_{3/2}\rangle \rightarrow |2(^4I_{9/2}),{}^2G_{5/2},{}^4F_{3/2}\rangle$).



WL3

DOUBLE IR RESONANCE STUDY OF VIBRATIONAL RELAXATION OF METHYL FLUORIDE IN SOLID RARE GAS SOLUTIONS NEAR THE MELTING POINT

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The straightforward analysis of various vibrational relaxation mechanisms in dense media, with possible effects of structure of molecular nearest environment, could be performed on the basis of wide-range temperature measurements, including the phase transition region. But experiments on selective excitation of molecules performed at these conditions are very scarce up to now. In the present study results on methyl fluoride(CD_3F and CH_3F) diluted in solid and liquid Xe, Kr, Ar near the melting points are considered for the first time. Vibrational relaxation time has been measured by the double IR resonance method in the range 170 to 80 K. Technics of transparent solid sample (l=3 cm) growth from liquid rare gas solutions of $CH(D)_3F$ is similar to that used earlier for CD_3F in Xe. Typical dilutions in liquid and solid phase exceeded 20000. At these conditions, there were not oligomer formation and the measured decay time τ did not depend on $CH(D)_3F$ concentration. To populate the ν_3 level of CD_3F (CH_3F) 10R(26)-(36) (9P(26)-(36)) lines of a home made pulse TEA CO_2 laser (E<40 mJ/cm^2, 180 ns duration) was used. A CW CO_2 laser was used as a probe. Double resonance signals were observed at more than 20 lines of the probe laser. Decay parts of selected signals were well approximated by one exponent with the lifetimes τ close together. The observed trend of the relaxation rate decreasing, when going to lower temperature, is described by the IBC model quite satisfactory. But this model fails to reproduce a small observable hopping decrease of the rate at liquid to solid phase transition. Such discontinuity is in agreement with predictions of the simple cell model. The overall analysis of the experimental data shows that the IBC mechanism gives better results in the case of less dense liquid and solid media characterized by a weaker perturbation of guest rotational motion. But when going to lower temperature, the collective mechanism of rotation dominated vibrational deactivation of selectively excited methyl fluoride tends to be more efficient as compared to the V-T relaxation by binary collisions.

The research was supported by the Russian Foundation for Fundamental Research (Grant No 97-03-3363a).

WL4

Measurement of Plasma Fields with Polarization-Sensitive Coherent Four-Wave Mixing

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Coherent four-photon spectroscopy has long proved to be a convenient and efficient method for a diagnostics of excited and ionized gases, including temperature and concentration measurements in combustion and flames (e.g., [1]). The possibility of local nonperturbing measurements of electric fields in excited gas media and plasmas [2] by means of four-photon techniques has yet to be adequately analyzed.

In this paper, we demonstrate that polarization-sensitive coherent four-wave mixing (FWM) can provide an important information concerning the magnitude and orientation of electric dc fields and correlations of microfield fluctuations in plasmas. Consider a signal resulting from FWM of two light waves with frequencies ω_1 and ω_2 and a dc electric field $\bar{E}$, which includes an external dc field $\bar{E}^e$ and a fluctuating internal plasma field $\bar{E}^f$. In the case when vectors $\bar{E}_1$ and $\bar{E}_2$ of incident light fields are parallel to the x-axis, the intensity of the FWM signal transmitted through a polarization analyzer (Fig. 1) oriented along the x- and y-axes is written as

$$I_x \propto \left|\chi^{(3)}_{1111}(\omega_s;0,\omega_1,-\omega_2)\right|^2 I_1 I_2 \left\{\left|E^e_x\right|^2 l^2 + B(l)l\right\},\quad I_y \propto \left|\chi^{(3)}_{1122}(\omega_s;0,\omega_1,-\omega_2)\right|^2 I_1 I_2 \left\{\left|E^e_y\right|^2 l^2 + B(l)l\right\}. \quad (1)$$

Here, $\chi^{(3)}_{1111}(\omega_s;0,\omega_1,-\omega_2)$ and $\chi^{(3)}_{1122}(\omega_s;0,\omega_1,-\omega_2)$ are the relevant components of the nonlinear-optical cubic susceptibility tensor, I_1 and I_2 are the intensities of the waves ω_1 and ω_2, l is the interaction length, and $B(l) = \langle E^f_x(0)\cdot E^f_x(z)^*\rangle = \langle E^f_y(0)\cdot E^f_y(z)^*\rangle$ is the correlator of electric-field fluctuations in an isotropic plasma. The spatial scale of plasma inhomogeneity is assumed to be less than the interaction length l.

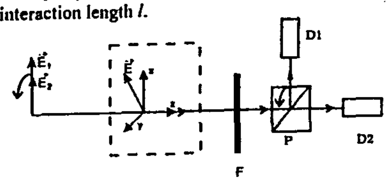

Fig. 1. FWM scheme for measuring dc electric fields in plasmas: F, filter; P, polarization prism; $D1$, $D2$, photodetectors

Thus, the intensity and polarization of the FWM signal involve both permanent and fluctuating components of the dc plasma field, which makes it possible to extract information concerning plasma fields by measuring the intensity and polarization parameters of the FWM signal. In particular, rotating polarization vectors of incident light waves simultaneously with the unit vector of the polarization analyzer (Fig. 1), we can determine the direction of the component of $\bar{E}^e$ perpendicular to the wave vectors of the incident light waves. To find the orientation of the vector $\bar{E}^e$, we should probe plasma at least in two different directions. The contributions of $\bar{E}^e$ and $\bar{E}^f$ to the FWM signal can be separated by means of polarization measurements due to the fact that these components, as can be seen from formulas (1), have substantially different polarization dependences.

This work was carried out as a part of scientific cooperation within the framework of «Basic Optics and Spectroscopy» Education and Research Center.

References

1. S.A.J. Druet and J.-P. Taran, *Prog. Quantum Electron.*, 7, 1 (1981).
2. O.A. Evsin, E.B. Kurpiyanova, V.N. Ochkin, S.Yu. Savinov, and S.N. Tskhai, *Quantum Electron.*, 15, 278 (1995).

WL5

Two-Photon Absorption Spectroscopy of Electronic Transitions in Cr_2O_3

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Chromium oxide Cr_2O_3 is a well known compound which has the corundum-type centrosymmetric crystal structure $\bar{3}m$. For many years it was a subject of numerous studies and recently a very rich second harmonic generation spectrum due to the spin ordering was observed in Cr_2O_3 below the antiferromagnetic Neel temperature T_N=307 K [1]. In this paper we report the first study of the two-photon absorption (TPA) spectra of Cr_2O_3 in the range from 2.5 eV to 3.6 eV. The spectra were studied at room temperature using three different polarization configurations. A broad band split into several sub-bands is observed in the region 2.7-3.1 eV, where the TPA coefficient reaches a value $\beta \sim 0.4$ cm/MW. A comparison of these data with the linear absorption spectrum of Cr_2O_3 shows that this broad band is due to the ${}^4A_2 \rightarrow {}^4T_1$ electronic transition in the $3d^3$ shell of Cr^{3+} ion in the crystal field. The TPA spectra are characterizaied by a more rich structure as compared to the linear absorption spectra. The observed structure can be assigned to the splitting of ${}^4T_1$ band by the trigonal component of the crystal field into ${}^4\Gamma_2$ and ${}^4\Gamma_3$ subbands. Besides that the additional structure of the TPA spectra can be assigned to the resonance enhancement of TPA when the probe beam photon energy coincides with the sharp ${}^4A_2 \rightarrow {}^2E$ transition at about 1.7 eV. No TPA was detected in the region from 3.1 to 3.4 eV. A strong TPA starts at $E_{g||} = 3.445$ eV for the polarization configuration $e_c \parallel e_p \parallel c$, and at $E_{g\perp} = 3.466$ eV for $e_c \parallel e_p \perp c$. A sharp increase of β above E_g is an evidence of the direct interband transitions between the valence and conduction bands.

[1] M. Fiebig, D. Fröhlich, B. B. Krichevtsov, and R. V. Pisarev, Phys. Rev. Lett. **73**, 2127 (1994).

WL6

PROCESSES OF ELECTRONIC EXCITATION ENERGY TRANSFER IN MOLECULAR SYSTEMS WITH FRACTAL DIMENSION: LASER FLUORESCENCE SPECTROSCOPY AND COMPUTER MODELING

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In present work the processes of electronic excitation energy transfer between dye molecules in molecular systems on the base polymeric-water solutions are investigated by laser fluorescence and computer modeling methods. The spatial distribution the dye molecules in the polymeric solutions depending on the composition, structures and sizes of macromolecules is explored by method of computer modeling. The electronic excitation energy transfer in this systems was studed by laser spectroscopy methods. The results of theoretical calculations and experimental process study of electronic excitation energy transfer in water-polymeric solutions of dye molecules are:

• The distribution of interacting molecules in investigated systems has fractal dimension. The value of fractal dimension of investigated systems depends on concentration of polymer, probability of the dye molecule adsorption on polymeric chains, size of polymeric sections.

• The fractal clasters are formed in solutions of polyions (polyelectrolytes) and ion dyes with the charge of different sign under certain concentrations of components. The local concentrating the interacting molecules of dyes in this clasters causes an increasing efficiency of photophysical processes, which is revealed at dynamic luminescence quenching .

• The heterogenetic systems (dissolve polyelectrolytes with different lengths of polymeric chains) are distinguished from homogeneous ones by presence of fractal clasters of different dimensions. Structure of such systems causes shape of the areas with different distribution the interacting molecules. In these areas the average distance between molecules decreases. Such structur organization of heterogenetic molecular systems causes an increasing of efficiency of electronic excitation energy transfer between dye molecules.

WL7

DEVELOPMENT OF OPTOELECTRONIC LASER SPECTROSCOPY FOR DIAGNOTICS OF TOXIC METAL TRACES IN LIQUIDS

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The increase of the laser spectroscopy sensitivity in studies of liquids of different nature (biological, wate, solutions etc.) is one of the present-day probems since the intracavity spectroscopic methods cannot be applied in this case. It is of special importance for a ceaseless control of different compounds traces.

To solve the problem we developed the method that is based on the use of spectroscopic analysis with the special choosing the multifrequency laser emission for special indicator compounds forming molecular complexes with the subsances under investigation. The indicator are immobilized in a film that is in contact with the liquid. In according to toxic metal concentration we use both absorption and quenching spectroscopy.

Mutiple increase in the sensitivity for the developed method is achived by a choice both of a) the special geometry of the laser radiation propagation in the film (up to going to surface waves) that allows to increase substantially the length of its interaction with indicator or to use the cooperative effects in the quenching process; b) the laser radiation spectrum according to spectral differences of the indicators and their complexes.

We have investigated comparatively the characteristics of indicator compounds and their complexes with metals that was aimed at the determination of optimum spectral properties of laser radiation and of optimum types of indicators that is effective for the immobilization in films. In particular in the work we present the results on determining the concentration of the mercury and lead salts using porphyrins (gemin and hematoporphyrin) as indicators. Now we work with different films (including with sol-gel technology). A multifrequency dye laser is used as an radiation source.

It should be noted that our results are of importance both for the solution of principal problems of liquid spectroscopy and also for development of new types of compact sensor devices which sensitivity is of several orders of magnitude greater than that now in use.

NEAR-FIELD RADIO-FREQUENCY MODULATED REFLECTANCE OF A SEMICONDUCTOR STRUCTURE

WL8

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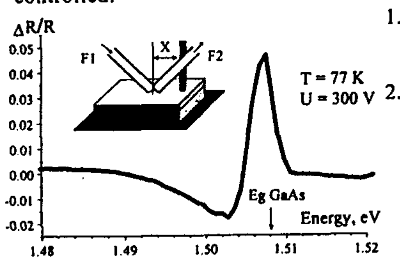
Recently, radio-frequency modulated reflectance (RMR) was proposed, as a novel method of modulation spectroscopy [1] and its advantage was shown at low temperatures with respect to traditional methods, such as photoluminescence (PL), electroreflectance and photoreflectance (PR). RMR principle consists in the radio-frequency electric field effect on a light reflectance from the structure. In this paper we show RMR spectra in Near-field configuration (NRMR) which demonstrate a dramatic change in the reflection magnitude and a far lateral spread of NRMR perturbation.

We investigated GaAs/AlGaAs heterostructures with two dimensional electron gas. Recently we have observed a large lateral photo-perturbation propagation in such samples, registered by local measurements of PL and PR [2]. To provide near-field radio-frequency perturbation, the sample was placed between the plate electrode and cylindrical (Ø100 μm) electrode. Amplitude modulated high frequency voltage was applied. Reflectance was measured by means of optical fibers F1 and F2 (figure insertion). Figure shows the near-field radio-frequency reflectance obtained when the probing light spot was separated from to the cylinder electrode by the distance X ~ 2 mm. The change in the reflectivity exceeds 4% in the energy region of GaAs band gap (1.508 eV). This is an order of magnitudes higher than the RMR effect in homogeneous perturbation case. Qualitatively the NRMR spectrum shape is described by a model of Ref.[1] which takes into account the modulation of the internal electric fields. However the exciton contribution to the spectra was not observed. The broadening of NRMR spectrum at E < Eg is explained by heating effects. Strong effect of modulated near-field on a light reflectance gives a new possibilities in the design of a high-speed optical modulators, with reflected beam profile being controlled.



1. O.A.Ryabushkin and V.A.Sablikov. JETP Lett. 68, No. 3 (1998) (to be published);
2. O.A.Ryabushkin, V.A.Sablikov, A.O.Volkov and V.G.Mokerov. Inst. Phys. Conf. Ser. No 155: Chapter 2, pp. 137-140 (1997), Proceeding of the International Symp. Compound Semiconductors 23, St. Petersburg, 1996

Binary solvent microstructure fluctuations revealed by picosecond polarization spectroscopy of fluorescent probe.

WL9

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It was shown in a last decade that fluctuations of solvent microstructure plays important role in spectroscopy of dye solutions. Nevertheless very little is known on the microstructure fluctuations of binary solvents though such solvents are of a great importance particularly in chemistry and biology. In spite of numerous investigations of atomic ions in binary solvents there is practically no information on the heterogeneity of such media caused by fluctuations of microstructure. In this work Rhodamine 6G was used as a fluorescent probe for investigation of microstructure fluctuations of water-alcohol and water-dioxane mixtures at different ratio of components. In particular the variation of solution microviscosity was determined by measurement of rotational diffusion time (τ_R) of the probe.

The values of τ_R were determined for both the ground (S_0) and excited (S_1) states of Rhodamine 6G molecules by time resolved measurement of photo-induced absorption dichroism and fluorescence anisotropy. We observed that the reduced rotational diffusion time is the same for pure water and pure methanol ($\tau_R/\eta \approx 280$ ps/cP, where η is solution viscosity). In both above cases then value τ_R/η does not depend on the wavelength when measured across absorption and fluorescence spectra. This feature proves the homogeneous type of electronic spectra broadening of Rhodamine 6G in the pure solvents. Nevertheless the addition of a small portion (~7%) of methanol to aqueous solution leads to noticeable decrease of reduced rotational diffusion time and at the same time to appearance of τ_R spectral dependencies for both S_0 and S_1 states. In particular for the ground state of dye molecule value of τ_R changes from 190 ps to 250 ps if registration wavelength is moved from 460 nm to 520 nm; for the excited state the change of τ_R from 210 ps to 270 ps is observed at the shift of registration wavelength from 560 nm to 630 nm.

Thus the inhomogeneous broadening of both absorption and emission electronic spectra of Rhodamine 6G shows up in result of alcohol additional to aqueous solution of dye. This inhomogeneous broadening is connected to statistical fluctuation of binary solvent viscosity as proved by variation of τ_R/η value. We have established at our experiments that the rotational diffusion time goes through maximum when the percentage of methanol in solution increases, the maximum corresponding to 15% of methanol content. At further increase of methanol concentration the inhomogeneous broadening of the fluorescent probe spectra as well as variation of solution microviscosity gradually lessen until completely disappear in pure alcohol. The observed specific behavior is the indication of the considerable statistical variation of the binary solvent microstructure accompanying by corresponding variation of its main physical properties. Special characteristics of dioxane as structure-breaker component are discussed.

WL10

NaCl CONCENTRATION AND WATER TEMPERATURE INFLUENCE ON THE RAYLEIGH WING BY FOUR PHOTON POLARIZED SPECTROSCOPY

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The hypersonic lattice resulted from the interaction of reference wave with the scattering medium leads to the anizotropic scattering nonlinear cubic susceptibility modulation and the formation of maxima in the Rayleigh wing displaced from each other to the Brillouin frequency in the range from -2 cm^{-1} to 2 cm^{-1}.

With the increase of NaCl concentration and water temperature it is observed the growth of water adiabatic compressibility and hence the increase of Brillouin threshold and the decrease of the anizotropic scattering nonlinear cubic susceptibility modulation degree.

With the modulation degree decrease the side maxima amplitude deminishes and is not registrated by the set. This result in the Rayleigh wing narrowing obtained by four photon polarized spectroscopy.

WL11

Laser induced fluorescence saturation for binary mixtures of organic luminophores

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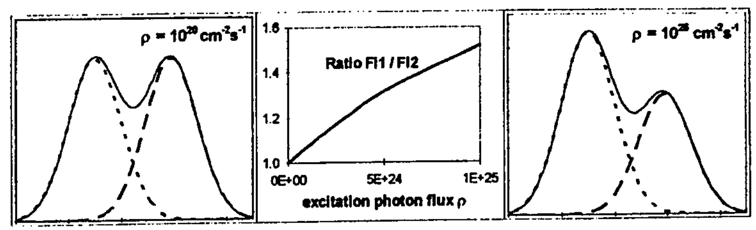
The effect of fluorescence saturation under laser pulsed excitation appears as a non-linear response of emission signal versus intensity of excitation [1]. The saturation becomes important when the rate of molecular excitation exceeds the rate of their deactivation. Typically the effect is noticeable when laser photon flux (ρ) exceeds $10^{24} cm^{-2} s^{-1}$ [2]. The fluorescence intensity normalized by Raman scattering signal from the solvent is used to describe quantitatively the effect of fluorescence saturation [1]. This standardization by Raman scattering is useful if the magnitude of Raman scattering signal is compatible with the intensity of fluorescence, and can be applied for the organic dye solutions at concentration up to $10^{-8}...10^{-6}$ mole per liter.

The new technique of quantitative luminescent analysis suggested in the work involves the investigation of binary mixtures of organic dyes. The ratio of fluorescence intensities for two emission bands is used as a quantitative characteristic of fluorescence saturation. The new approach is valid for diluted and concentrated dye solutions as well as for polymer films doped with dye molecules. The work presents the theoretical consideration of saturation curves for different molecular characteristics (absorption cross-section, fluorescence life-time) including the cases of intermolecular interaction in the solution (static and dynamic quenching, bimolecular interaction in the excited state).

Fluorescence spectra for binary mixture of organic dyes



1. Chekalyuk A., Fadeev V. et al, 1981. Opt. Comm., vol. 38, No 3, pp. 177-181.
2. Yuzhakov V., Yevsyukhina K., Patsayeva S., 1997. In: ALT'97. Advanced Laser Technologies. Intern. Conf. on Laser Surface Processing. Limoges, France. p. P20.

WL12

APPLICATION OF FEMTOSECOND LASER PULSES FOR NONLINEAR OPTICAL DIAGNOSTICS OF CHIRAL MOLECULES IN INTERFACES.

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Sum frequency (SFG) and second harmonic generation (SHG) are powerful techniques for a studying of matter and surfaces structure. These processes are forbidden in electric-dipole approach in isotropic substance with inversion symmetry center, but at the surface of the substance isotropic symmetry is broken and the SFG and SHG may occur. If we add the property of mirror-asymmetry to symmetry properties of the substance (in fact, such medium is solution of «chiral» molecules), the SFG and SHG processes from the sample surface will get unique specific. Contributions (local and nonlocal) from the sample bulk should be taken into account, as well as one from the pure surface, for a correct description of the processes.

We report the development of the method for investigation of chiral structure of molecular systems with femtosecond laser pulses based on SFG/SHG signal intensity measurement via polarization state of fundamental frequency beam. With this method, one has possibility to separate in experiment combinations of chirally-generate and chirally nonspecific components of nonlinear tensors of different origin (pure surface and bulk local/nonlocal). In our paper we show that analysis of polarization state of the output nonlinear optical signal is enough for detection of chirality, determination its relative value, «sing» and also for control of «chiral» solution composition.

WL13

MEASUREMENTS OF TPA CROSS-SECTIONS OF PHOTOCHROMIC SUBSTANCES

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Photochromic substances are the promising media for development of 3-dimensional memory devices using two-photon absorption (TPA) [1]. Using TPA it is possible to localize the photochemical transformation in a bulk of storage medium without any changes in the surrounding. Various schemes for TPA cross section measurement of the organic compounds have been developed [2]. However, these schemes can not be applied to measure non-linear optical properties of organic photochromic substances. The TPA measurement of photochromic substances is complicated by corresponding photochemical reaction. In this paper we report the results of TPA cross section measurements of the following photochromic substances: indolyl fulgide and naphthacenequinone derivatives. Femtosecond Ti-Sapphire laser is used as a source of radiation to initiate the two-photon reactions. CW Ar-ion laser is used as a pump source for Ti-Sapphire laser and as a probe beam for measuring photocolored form concentration. The values of TPA cross section have been defined using the measured photoinduced form concentration and known photoreaction quantum yield. Concentration of the photoinduced form has been obtained from either optical density measurements or fluorescence intensity ones. Absorption and fluorescence methods were used to measure the concentration of photoinduced form. The measured TPA cross sections is in range $1.5\text{-}2.3 \cdot 10^{-50}$ $cm^4 \cdot s$ for fulgide derivatives and 0.7-1.5 for naphthacenequinone derivatives.

References

1 Koroteev N.I., Magnitskii S.A., Shubin V.V., Sokoluk N.T., Jpn. J. Appl. Phys. 36, 424, 1997.

2 E.E.Alfimov, D.E.Groshev, ...Optica i Spectroscopia (Rus), v.78, p.400 (1995) Meshalkin

WL14

FLUORESCENCE SPECTRUM OF NA ATOMS EXCITED BY TWO EVANESCENT WAVES

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Resonant optics at a gas-solid interface is of great interest mainly due to its high sensitivity to the atom-surface potential. In this work we have evaluated experimentally and theoretically the possibility to study the atom-surface interaction with a new, largely background-free technique, namely excitation of the fluorescence spectrum of Na atoms by two counterpropagating evanescent waves (EW's) at a glass prism-vapor interface. One of the contributing lasers was set in resonance with the Na $3P_{3/2} \rightarrow 5S_{1/2}$ transition, while the other one was scanned across the $3S_{1/2} \rightarrow 3P_{3/2}$ resonance (pump laser). The fluorescence emitted from the intermediate $4P_{3/2}$ state to the ground state was registered by a UV-sensitive photomultiplier. The spectrum consisted of four Doppler-free hyperfine components corresponding to two-quantum transitions between the hyperfine sublevels of the ground and the upper excited states. The fluorescence lines exhibited with an increase of pump laser power a splitting proportional to the EW amplitude, which became smaller with decreasing prism surface temperature.

The corresponding theory of fluorescence excited by two EW fields has also been developed in this work based on a density matrix approach. The observed splitting can be understood as the Autler-Townes effect in a Doppler-broadened three-level system. The main contribution to the line center intensity arises from the atoms moving almost parallel to the prism surface, which interact with the surface potential for a long time. As a consequence, the observed splitting provides information on the atomic transition moment near the surface.

WL15

EXPERIMENTAL INVESTIGATION OF NON-STEADY EFFECT OF SPATIAL MODULATION OF LUMINESCENCE INTENSITY IN CRYSTALS UNDER FEMTOSECOND EXCITATION

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The described phenomenon is realized in the fact that luminescence of homogeneous crystals registered in the direction orthogonal to the wave vector of the excitation beam, is periodically modulated over distance [1]. Modulation period corresponds to the period of change of the state of light polarization at propagation through the crystal. The said phenomenon is observed only in anisotropic luminescent quantum systems oriented in the crystal at an angle around $\pi/4$ to the optical axis. With this angle, the depth of modulation of luminescence intensity is close to 100 per cent. It decreases to zero for quantum systems oriented along or orthogonal to the optical axis. As the result of calculation, we have discovered that for femtosecond laser pulses with Gaussian time envelope, the spatial envelope of luminescence intensity modulation depth also follows the Gaussian curve. The width of this envelope Y is directly related to the dephasing time constant T_2 in two-level quantum systems - in case of their coherent excitation, or to the pulse duration in the incoherent case.

Experiments were done with uniaxial crystals of sapphire and magnesium fluoride. The quantum systems that we studied were the anisotropic color centers. They possessed the symmetry required, and were created by the radiation technology. Sapphire crystals were irradiated with fast neutrons in a nuclear reactor. For irradiation of magnesium fluoride we used gamma rays. For excitation of luminescence the second harmonics of a titanium-sapphire laser tunable in the 370-450 nm range was used. Pulse duration varied from 70 to 210 fs. Experiments were carried out at 300K and 78K. We observed ordinary luminescence with corresponding Stokes shift. It was discovered that the parameter Y follows the duration of excitation pulses, which testifies for the incoherent excitation. However, it does not mean that the time constant T2 is less than 70 fs for the centers studied. It is necessary to consider the electron-phonon broadening of electron states and corresponding relaxation transitions through the phonon sublevels, following thermalisation of excitation. The value of Y for hot luminescence bears information about probability of phonon relaxation. Under excitation and observation of luminescence caused purely by electron transitions, the value of Y is defined by the time of decay of coherency in motion of excited quantum systems.

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[1]. E.E.Martynovich, E.F.Martynovich, S.I.Polityko. OQE, 1995, v.27, pp. 725-734.

WL16

LASER-INDUCED ATMOSPHERIC TRANSMISSION WINDOWS IN INFRARED

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To extend the capabilities of remote spectral diagnostics of small gas constituents it is very desirable to reduce strong interfering absorption of non-pollutant components (e.g., H_2O and CO_2) dominating in infrared and microwave regions. We present an accurate theoretical model and simulation results for nonlinear IR high-resolution absorption spectra of atmospheric air aiming to study its laser bleaching. Line-by-line spectra are computed using: HITRAN data base and Voigt contour for each individual absorption line, modified empirical water vapour continuum model in 3-5 μm and 8-12 μm transmission windows, six season-latitude atmospheric models containing vertical distributions of total pressure, temperature and partial pressures of atmospheric gases in 0-120 km altitude range. Time-dependent vibrational levels populations are modelled using kinetic equations accounting for state-by-state vibrational relaxation and laser excitation processes. Rotational relaxation is taken into account in laser excitation. The calculations were made for horizontal sea level and stratospheric paths for selected CO- and HBr- laser frequencies coinciding well with very strong 6,27 μm H_2O and 4,3 μm CO_2 absorption lines. The effects of vibrational and vibration-rotational population inversion in CO_2 and H_2O molecules are found and studied numerically and, in some cases, analytically. In particular, marked inversion of CO_2 vibrational levels has been found to occur even at moderate laser intensities resulting in negative absorption in 8-12 μm transmission window. The possibility to control the transmission micro-windows in 6,27 μm H_2O band is demonstrated as well.

WL17

LASER SPECTROSCOPY OF HELICAL LIQUID CRYSTALS

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The sharp increase of thresholds for modes with an index greater than N= $\pm$ 1 in the laser with distributed-feedback (DF) based on cholesteric liquid crystals (ChLC) [1] makes it possible to determined different distortion of supermolecular structure of liquid crystals by means of emitting spectra of such a laser.

The generation spectra of a DF-laser based on cholesteric liquid crystals (ChLC) characterized by different way of helical structure formation have been studied.The experimental equipment and methods similar to those descripted in [1] have been used.

The experiments were carried out with three typs of ChLC: steroidal with halfwidth of the selective reflection (SR) bands $\Delta\lambda \approx 20$nm, a mixture of nematics and steroidal ChLC ($\Delta\lambda \approx 60$nm), and a ChLC with helix induced by nonmesogen chemical additive ($\Delta\lambda \approx 90$nm). Depending on correlation between $\Delta\lambda$ SR and $\Delta\lambda$ the emission band of doping dye which was the one lasing band in the center of SR-band, two bands on its edges and one lasing band, which position was changed nonsynchronously with concentration change of a helix pitch. The thin structure of lasing spectrum that shows the unordering of planar texture is appeared while increase layer thickness more than 60 μκ. The heating of ChLC by exite emission revealed in monotonous and symmetrical widening of lasing spectrum line.

In order to explain the experiments the theory of harmonic distortion of supermolecular structure of ChLC with induced helix [2] have been used. A fairly good coincidence of the experimentally measured periods with calculated ones were obtained.

1. I.P.Il'chishin. Bulletin of the Russian Academy of Sciences. Physics. 1996, v.60, №3, p.494.
2. E.D.Belotskyi, P.M.Tomchuk and B.I.Lev. Mol. Cryst. Liq. Cryst.1991, v.209, p.179.

WL18 DUAL BROADBAND CARS THERMOMETRY *IN H_2/O_2 ATMOSPHERIC PRESSURE DIFFUSION FLAME*

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The aim of the present study is to investigate the abilities of the dual-broadband CARS (DBB-CARS) spectroscopy of the Q-branch of H_2 for single shot temperature measurements. DBB-CARS seems to be preferable than the conventional broadband- or 2λ-CARS since the most efficient averaging over the spectra of laser radiation can be achieved, providing the improvement of the precision of temperature measurements.

The laser system of the CARS-spectrometer employed consists of a repetitively-pulsed frequency-doubled Nd:YAG laser (bandwidth ~ 0.7 cm^{-1}, mode spacing ~ 0.005 cm^{-1}) pumping one modeless and one broadband dye laser providing DBB pump radiation in two regions of wavelength near 553 nm and 713 nm. The modeless radiation was obtained from a longitudinally pumped dye oscillator based on two-pass amplification of spontaneous emission. The spectral width of each of the beams, with the pulse energies of about 2 mJ, was about 200 cm^{-1}.

The DBB-CARS technique is characterized by thermometry in atmospheric pressure premixed H_2-air flame of the McKenna burner in the range of 1200-1900 K. The estimated error of the DBB-CARS single-shot temperature measurements is about 4-5% at 1500-2000 K, as compared to about 10-12% provided by our 2λ-CARS thermometry using S-branch transitions of H_2. The results of temperature mapping of a laboratory H_2/O_2 atmospheric pressure diffusion flame with coaxial gas injection are presented. Temperature evaluation in the range of 1000-3000 K is performed with the error of about 5%. The analysis of the precision of the single-shot measurements is given.

WL19 CARS STUDIES OF COLLISIONAL SPECTRAL EXCHANGE IN THE HOT ISOTROPIC Q-BRANCHES OF CO_2

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CARS spectra of the $(11^10)_{1,2} \leftarrow (01^10)$ isotropic Q-branches of $^{12}C^{16}O_2$ at 1409 cm^{-1} and 1265 cm^{-1} were recorded with the resolution of 0.08 cm^{-1} in the range of 0.3-50 Amagat (T=295 K) employing a standard scanning pulsed CARS-spectrometer [1]. Due to vibrational l-doubling the rotational constants for the even- and odd-J levels of the bending vibrational states are different. Thus, each of the studied bands consists of a pair of unresolved Q-subbranches. If one assumes even-ΔJ collisional transitions to be the only allowed ones (as it rigorously holds for the CO_2 states with zero vibrational momentum), odd- and even-J manifolds are collisionally uncoupled, and a doublet of the motionally narrowed Q-subbranches should appear at elevated densities. In both bands, however, such density-induced splitting was not observed by us.

To explain this quantitatively, the modifed strong collision model was extended to admit the inter-subbranch coupling by the odd-ΔJ collisional transitions which become allowed when the vibrational momentum is excited. This model incorporates also even-ΔJ transitions and vibrational broadening and shift, that provide an overall agreement with the measured profiles in the whole density range. Our results thus confirm the possibility of the collisional odd-ΔJ transitions in the bending states of CO_2, in accord with the recent CARS study of the $(11^10)_1 \leftarrow (01^10)$ Q-branch at lower densities [2].

References

[1] A.P.Kouzov, D.N.Kozlov, and B.Hemmerling, Proceedings of ECW'97, B-20, Heidelberg, Germany (1997).

[2] L.Bonamy, J.Bonamy, D.Robert, A.Deroussiaux, and B.Lavorel, J.Q.S.R.T., 57, 341 (1997).

WL20

INSTANTANEOUS HEATING AND TEMPERATURE MEASURING OF THE LOCAL VOLUME INSIDE WATER&ICE SAMPLES BY REMOTE LASER TECHNIQUE

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In many problems of laser pulse effect on substance the local heating of media plays key role, for example, in thermochemistry and laser biophysics. On the other hand, in laser spectroscopy of transparent samples this phenomenon can result in uncontrollable heating and change of the researched volume physical properties, limited by focal area of the laser beam. Especially it is important for the high intensity beams, as in nonlinear spectroscopy of the crystals, solutions and biological objects. In this case insignificant factor of absorption in sample for a pulse can change the temperature on dozen degrees in the beams intersection area.

We have developed a new method to measure the temperature of the aqueous solutions without contact base on the lidar backscatter technique and the temperature deformation of spontaneous Raman band contour. By using this method we can register the temperature enhancement inside bidistillated water and ice sample focal volume. The temperature increasing on (10÷30) degrees is proportional to the changing of pulse repetition rate from 0.5 up to 8 Hz were observed.

In experiment the shift of the Raman band envelope contour center was registered. In the water the slope factor has made 0.075 nm/Hz or 2 deg/Hz, and in the ice sample one twice more - 4 deg/Hz at our experimental conditions. This discrepancy can be resulted in different factors of energy absorption, first of all, and energy dissipate inside the focus volume.

Thus, the possibility of remote heating and instant temperature measuring for the laser pulse in transparent samples, especially, at high reprate have been shown experimentally.

WL21

PUMP-PROBE FEMTOSECOND EXPERIMENTS AND PHOTOINDUCED EFFECTS IN DC-ELECTRIC FIELD INDUCED SECOND HARMONIC GENERATION IN *Si(001)*-BASED *MOS* STRUCTURES

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Photoinduced effects in DC-electric field induced second harmonic generation (EFISH) are studied experimentally and theoretically in *Si-SiO₂-Cr MOS* structures at the subpicosecond time scale.

Experimental EFISH studies are performed using pump-probe configuration and photomodulation technique, for which two beams of the splitted output of a tunable femtosecond Ti-Sapphire laser are used as a pump and probe radiation. The pump beam generates electron-hole pairs in conduction band of subsurface Si layers, whose injection changed the space charge region parameters of the MOS structure. The probe beam generates the second harmonic radiation from the silicon subsurface regions with photomodified parameters. The pump intensity is modulated by the chopper at 100 Hz to increase the sensitivity of the measurements. Illuminating the MOS structure shifts the minimum of the EFISH intensity (I_{on}) bias dependence and changes the shape of "quasyparabolic" curve in comparison with the one for unpumped MOS structure (I_{off}). Photomodulation efficiency $\alpha_{ph} = (I_{off}-I_{on})/I_{off}$ depends on applied bias and is found to be sensitive to the doping type, to the doping concentration, and interface trap concentrations as well as to the photon energy.

Theoretical description of the EFISH photomodulation effects is based on the model considering the kinetics of DC-electric field spatial distribution in the space charge region with the bulk and surface recombinaitons being taken into account. Model calculations consistently describes experimental dependences of photomodulation efficiency while changing the type and the value of doping concentration. This allows one to estimate the surface recombination constant.

Showing new features and increase of sensitivity to the changes of MOS-structure parameters in comparison with DC-induced SHG, the photomodulation EFISH techniques gives additional information about buried Si-SiO_2 interface properties.

WL22

SECOND-HARMONIC GENERATION INTERFEROMETRY AS A PROBE OF THIN INHOMOGENEOUS FERROELECTRIC FILMS

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Recently optical second harmonic generation (SHG) and hyper-Rayleigh scattering (HRS) are shown to be a powerful tool for studying the structure and correlation properties of thin inhomogeneous films. We show here that the measurements of the phase of second-harmonic (SH) waves, in other words the SHG interferometry, allows one to get the new microstructure characteristics of random inhomogeneous medium, which are additional to the correlation length of the random nonlinear polarization obtained by the conventional HRS.

Thin $Pb(ZrTi)O_3$ films of about 200 nm thickness consisting of randomly oriented column-like noncentrosymmetric microcrystallites (PZT ceramics) are studied. For the SHG interferometry experiments a fundamental radiation at 1064 nm from the output from a YAG:Nd^{3+} laser is used. The SH wave generated while reflecting the fundamental radiation from the sample interferes with the SH wave, generated in the reference (the thin tin oxide film is used). Interference patterns are obtained by moving the tin oxide film along the fundamental wave propagation direction. Interference patterns are obtained in both "allowed" p-in, p-out and in "symmetry forbidden" in homogeneous films s-in, s-out polarization combinations (PC). The interference pattern in "allowed" PC gives the magnitude and the sign of effective nonlinear susceptibility of the inhomogeneous film. The occurence of the interference pattern for s-in,s-out PC is due to the fact that the SHG signal generated by the reference is then incoherently scattered (and as a result partially depolarized) by the sample. For this reason the depolarized components of the SHG signals from the reference and from the sample are statistically dependent and undergo optical interference that is observed for s-in,s-out PC. The contrast of interference pattern can be considered as a measure of fluctuations of the local field factor that describes the linear response of the sample induced at the SHG frequency by the electric field from the quadratic polarization of the medium.

WL23

DIAGNOSTICS OF SURFACE AND BULK STRUCTURAL PHASE TRANSITION IN $SrTiO_3$ SINGLE CRYSTAL BY SECOND HARMONIC GENERATION

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Second harmonic generation (SHG), has often been used to study structural phase transitions in solids, in particular the phase transitions from a non-centrosymmetric to a centrosymmetric phase, as it is extremely sensitive to this. We show here that the sensitivity of SHG to the spatial fluctuations of the order parameter allows one to study the details of a phase transition from a centrosymmetric to another centrosymmetric phase and to distinguish the contributions to the SHG intensity from the bulk and from subsurface layers of a crystal.

The structural phase transition at T_c=105 K, from a *m3m* to *4/mmm* phase, was studied by means of the SHG technique with the use of a femtosecond Ti: sapphire laser in a single crystal of $SrTiO_3$ for two geometries: in reflection and in transmission. The thickness of the subsurface layer of the crystal probed by SHG is determined by the coherence length of the nonlinear interaction, that is about 50 nm for the reflection geometry, and about 0.1 mm for the transmission geometry. The temperature dependences of the amplitude of the reflected and transmitted SH waves differ from each other for both *s*-in, *p*-out and *s*-in, *s*-out polarization combinations. This points to the different temperature dependences of the bulk and surface nonlinear susceptibilities and therefore to the different temperature behavior of the structure in the bulk and subsurface region of the crystal. This effect has been observed recently by X-ray scattering as well, but with smaller spatial resolution.

WL24

NANOLOCAL TIME-RESOLVED OPTICAL STUDY USING SCANNING PROBE MICROSCOPE

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New method of time-resolved optical study with high spatial resolution using femtosecond laser pulses focused on (metallic) tip of scanning probe microscope is considered.

The system may be incorporated,e.g.,into the set for pump-supercontinuum probe studies,i.e. the method can give high time, spatial and spectral resolution simultaneously. The last occur to be compatible with uncertaintity principle.

Excitation of eigenmodes (plasma oscillations) in the system tip-substrate and their field localized near the tip are analized.

WL25

NONLINEAR OPTICAL TOMOGRAPHY of an INHOMOGENEITIES of REFRACTIVE INDEX

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The application of nonlinear mediums in systems of optical information processing is connected to necessity of monitoring of their parameters. The space inhomogeneity of refractive index of such mediums originating, for example, during cultivation of crystals, influences efficiency of nonlinear wave processes. Among modern methods of nondestructive researches of physical objects most informative is computed tomography. In the present work is shown that the integrated character of an outcome of nonlinear interaction of a probing radiation with a medium allows to put a problem of tomographic diagnostics of located and smoothly distributed inhomogeneities of refractive index. In an approximation of geometric optics of smoothly inhomogeneous mediums the process of deriving of tomographic projections for case of interaction three locally plane waves is considered. In difference from case of a homogeneous nonlinear medium, the phases of interacting waves are determined by geometric optical eikonals, have a sense of integrals along rays trajectories from refractive indexes. For want of it a projection is understood the distribution of a radiation by one from interacting waves outside of a researched medium in a plane, perpendicular to a direction of propagation. For unambiguous reconstruction of a structure of an inhomogeneity by tomographic method, the realization of probing in several directions is necessary. The feature offered nonlinear optical tomography is, that the effective interaction is possible in directions close to directions of the phase matching. This circumstance limits possibilities of deriving of large number of projections and results in a problem of reconstruction of a structure of an inhomogeneity on small number of projections, which frequently meets in optical tomography.

ON POSSIBILITY OF SPECTROSCOPY WITH THE SUB-DOPPLER TIME RESOLUTION IN THIN GAS CELLS

WL26

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New methods of stationary sub-Doppler spectroscopy of atoms (molecules) were developed in the case of the thin gas cell, whose length l is essentially less than the diameter of the laser beam [1-3].

In present paper we show that non-trivial nonstationary optical phenomena also take place in such cells, which open new possibilities for spectroscopy with the high time resolution. Indeed, the relaxation of populations and coherences of long-lived atomic states (for example sublevels of the ground term) occurs to equilibrium values mainly as a result of collisions of atoms with butt-end walls of the thin cell. Given relaxation is determined by the transit time $\tau = l/|v|$, where v is the velocity component of an atom along the cell. The gas in the cell is sounded by the running monochromatic wave with the fixed frequency ω close to the centre Ω_0 of the quantum transition under investigation from the long-lived level. According to the Doppler effect, the wave is absorbed in the main by atoms with velocity projections v close to the value $(\omega-\Omega_0)/k$ [4], where $k=\omega/c$. Thus we can directly determine the frequency detuning $\delta=(\omega-\Omega_0)$ by registration of the characteristic time $kl|\delta|^{-1}$ of the absorption relaxation of this wave (after the action of the pumping pulse). Hence, unlike known methods of spectroscopy with the time resolution [4], it is possible to find the centres of Doppler broadened spectral lines of atoms on the dynamics of the absorption of the radiation with the fixed frequency.

REFERENCES

1. Izmailov A.Ch.// *Laser Physics.* 1992. V.2. P. 762 ; *Opt. i Specrosk.* 1993. V. 74. P. 41.
2. Izmailov A.Ch.// *Laser Physics.* 1993. V. 3. P.507; *Opt. i Specrosk.* 1993. V. 75. P. 664.
3. Briaudeau S., Bloch D. and Ducloy M. // *Europhys. Lett.* 1996. V. 35. P. 337.
4. Demtroder W. *Laser Spectroscopy : Basic Concepts and Instrumentation. Heidelberg: Springer.* 1996.

INVERSE CROSSOVER RESONANCE IN DOPPLER-FREE ^{87}Rb SPECTRUM

WL27

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We report about an experimental observation of alignment induced resonance in Doppler free spectrum of D_2 absorption line of ^{87}Rb (λ=780nm). The resonance appeared as a peak of absorption instead of transmission peak at the position of crossover resonance between the $5S_{1/2}(F=1) \rightarrow 5P_{3/2}(F=0)$ and the $5S_{1/2}(F=1) \rightarrow 5P_{3/2}(F=1)$ transitions. Earlier the resonances of the same nature were observed in [1] for ^{85}Rb isotope. In our case the chosen transitions provide maximal amplitude of the effect due to simplest structure of magnetic sublevels. The effect was observed in conventional laser setup for saturated absorption spectroscopy.

Maximal amplitude of observed resonance was achieved in weak magnetic field oriented along the polarization vectors of linearly polarized probe and strong laser beams. In this conditions both $5S_{1/2}(F=1) \rightarrow 5P_{3/2}(F=0)$ and $5S_{1/2}(F=1) \rightarrow 5P_{3/2}(F=1)$ transitions have full and fast alignment effect in the presence of strong field. For the first of them the population of the ground level was accumulated at the $m_F=+1,-1$ Zeeman sublevels, and for the second it was accumulated at the $m_F=0$ sublevel. As a result, when the strong field was tuned on the first resonance and the probe one was tuned on the second, the absorption of probe beam becames high. The same effect was observed at inverse tuning.

The most remarkable feature is that when laser frequency is at the position of crossover resonance both of this situations take place. The probe absorption is a sum of two signals, corresponding to two groups of atoms moving in opposite directions. For one of them the strong beam is tuned to the $5S_{1/2}(F=1) \rightarrow 5P_{3/2}(F=0)$ resonance and the probe beam is tuned to the $5S_{1/2}(F=1) \rightarrow 5P_{3/2}(F=1)$ resonance. For the another group the situation is inverse. Then we have doubled increase of probe absorption instead the increase of the transmission at the crossover resonance.

The amplitude of the resonance could serve a convenient measure of alignment in Rb vapor. It depends upon the relation between the alignment rate and the rate of relaxation of ground state Zeeman sublevels and may be calculated numerically. Such calculations were developed in [2] for the D_2 line of ^{85}Rb isotope. Also one can see that the width of the resonance is noticeable less than the widths of another peaks. The reasons of this effect will be discussed.

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[1] S. -S. Kim, S. -E. Park, H. S. Lee, C. H. Oh, S. -D. Park, and H. Cho, Jpn. J. Appl. Phys. **32**, 3291 (1993).
[2] S. Nakayama, Jpn. J. Appl. Phys. **24**, 1 (1985).

WL28

Sub-Doppler Laser Spectroscopy of atoms with photoinduced electron transfer to the Solid Surface

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The photoionization spectroscopy of atoms (molecules) has a very high spectral and time resolution and sensitivity [1]. The disadvantage of this method is a low photoionization cross-section that requires high intensity laser light for the ionization of resonant exited atoms.

As shown experimentally in [2] the exited atom colliding with the metal surface can ionized effectively when its "reduced" ionization energy becomes less then the work function of the metal. These phenomena called surface resonance photoionization (SRPI) have been used for the high resolution spectroscopy of atoms interacting with the metal surface [3,4].

In the present paper the Sub-Doppler spectra of the thermal velosity atoms exciting by tunable coherent laser light near the surface have been obtained. They are dramatically depends on the direction of the laser beam to the surface.

We consider the SRPI-spectrum of atom taking into account the interference effect of continuum allowed electronic states above the Fermi level in the metal and excited atomic states localized opposit the continuum. For the theoretically analysis Anderson-tipe hamiltonian and density matrix equation for the atom-surface system are used. The theory predicts asimmetry for the SRPI-spectrum analogous to the Phano autoionization resonans for the free atoms. Results shows the possibility using of the photoinduced electron transfer processes from the atom to the metal for the very high resolution spectroscopy.

1. Lefokhov V.S. Laser photoionizatlon spectroscopy, M.1987.
2. Malyshev G.F. Telegin G.G., In "Laser Beams"; N Berger, Ed., Khabarovsk, 1981, P.67; J.T.P. 1986, V.56, N6, P.1195.
3. Auschwitz B., Lacman K. //Chem. Phys. Lett., 1985, V.113, N2, P.230.
4. Kolchenco A.P., Telegin G.G.//Optics and spectroscopy, 1989, V.66, N6, P.1272.

WL29

Coherent Ellipsometry of Atomic Hyper-Raman Resonances in Laser-Produced Plasmas

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Coherent ellipsometry, i.e., the measurement of parameters of the polarization ellipse corresponding to the signal of four-wave mixing (FWM), is one of widely applied modifications of polarization-sensitive four-photon spectroscopy. For Lorentzian lines, in many important situations, coherent ellipsometry makes it possible [1] to determine the ratios of the invariants of the hyper-Raman scattering tensor and to separately study the frequency dependences of the real and imaginary parts of the nonlinear-optical cubic susceptibility.

However, the approximation of Lorentzian contours is not always applicable for the description of atomic and ionic spectral lines in a laser-produced plasma [2].

In this paper, we propose a technique for determining invariants of the hyper-Raman scattering tensor and for resolving closely spaced FWM spectral lines of an arbitrary shape. The method for determining the spectral dependences of the real and imaginary parts of the third-order nonlinear-optical susceptibility will be extended to arbitrary spectral lines. The developed approach was used to analyze the data of FWM spectroscopy and coherent ellipsometry of a ~~low-temperature~~ laser-produced plasma (Figs. 1a and 1b). It is demonstrated that, under certain conditions, the processing of the data of coherent ellipsometry by means of the proposed procedure makes it possible to reconstruct both the spectral and temporal dependences of the interfering components of the third-order polarization of a medium.

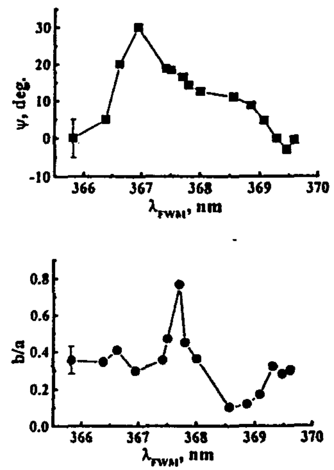

Fig. 1. Frequency dependences of (a) the tilt angle and (b) the ellipticity of the FWM signal.

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References

1. S.A. Akhmanov and N.I. Koroteev, *Methods of Nonlinear Optics in Spectroscopy of Light Scattering* (Moscow: Nauka, 1981).
2. N.I. Koroteev, A.N. Naumov, D.A. Sidorov-Biryukov, and A.M. Zheltikov, *Laser Phys.*, 7, 45 (1997).

Four-wave mixing investigation of nonlinear resonant properties of Nd^{3+}:YAG and Cr^{4+}:YAG.

WL30

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Absence of full knowledge of the resonant susceptibility of laser crystals (LCs) and saturable absorbers (SAs) leads to underestimation of refractive index changing in explaining different nonlinear-optical effects which are very important for understanding the complicated laser dynamics and construction of new laser architectures. In the majority of the previous experiments the resonant wave mixings (using nonlinearity of saturation of the working transition) in inverted LCs or SAs are explained by the gain or absorption grating (GG or AG) formation (see, for example [1,2]). On the other hand, it is well known, that the LCs (or the SAs) have different refractive indexes due to difference in polarizability of excited and unexcited rare-earth or transient metal ions, like Nd^{3+}, Cr^{4+} and others. Therefore, the population grating (PG) induced by the interference field of the resonant optical beams in laser amplifiers or SAs causes not only the GG or AG but also the refractive index grating (RIG). The aim of our investigations is comparable studying of the different gratings accompanying the PG in Nd^{3+}:YAG amplifier and Cr^{4+}:YAG absorber by using both nondegenerate and degenerate four-wave mixings (NFWM and DFWM).

In our experiments the PG was induced by the interference field of the optical beams of a cw Nd:YAG laser (at 1064 nm) intersecting in inverted Nd:YAG rod (or Cr:YAG sample). The RIG caused both by the PG and thermal grating was read by the optical beam of another laser (RUBY-laser or Nd:glass laser). In this way, we separated the resonantly induced RIG from the (or the AG). To separate the thermal and electronic contributions to the RIGs we investigated mitting and reflecting geometry of the writed gratings. The diffraction efficiencies of these gratings were also compared using DFWM. It was observed that for Nd:YAG and Cr:YAG crystals the RIG and the GG (or the AG) gave comparable contributions, ratio between which for Nd:YAG depends on the value of optical pumping.

The diffraction efficiency of the steady-state gratings accompanying the PG was determined analytically and calculated numerically. The comparison of the theory and the experiments allowed us to define the resonant susceptibilities of the crystals.

1. A. Brignon , J.-P. Huignard, Opt. Lett., 18, 1639 (1993).
2. M.J. Damzen, R.P.M. Green, and K.S. Syed, Opt. Lett. 20, 1704 (1995).

ZEKE PFI SPECTROSCOPY OF NAPHTHALENE VAPORS VIA S_2 ELECTRONIC STATE

WL31

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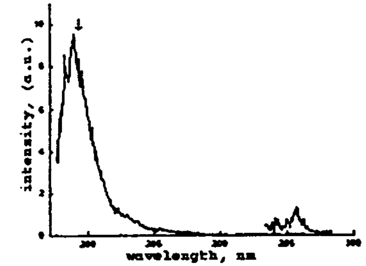
The one-color two-step laser excitation is used to populate the naphthalene Rydberg states with high principal quantum numbers (n>130) in the energy region 66500-72000 cm^{-1} via S_1 and S_2 electronic states. The frequency-doubled radiation of the dye laser is focused into the ionization chamber with naphthalene vapors (10^{-5} Torr). The Rydberg states are ionized by the delayed for 0.5 μs electric field pulse (~ 1 V/cm). The forming



electrons with "zero" kinetic energy (ZEKE PFI electrons) are detected. The naphthalene ZEKE PFI spectrum (Fig) consists of the two groups of electrons. The first one (near 296 nm) corresponds to the two-step ($S \rightarrow S_1 \rightarrow S_{Ry}$) excitation of the high n Rydberg states converging to the ground ionic state of naphthalene D_0. This group has been studied thoroughly in other laboratories. The second group of ZEKE PFI electrons (near 279 nm) has been observed at the first time. It can be assigned to the field ionization of the high n Rydberg states converging to the first electron-excited ionic state of naphthalene D_1 (an arrow in Fig. marks the one-half of the ionization energy obtained by one-photon photoelectron spectroscopy). The Rydberg states are populated via S_2 electron-excited state of naphthalene. We have found that the lifetimes of the superexcited states with the energy excess (above the first ionization energy) up to 1 eV are about 1 μs.

WL32

OPTICAL REFLECTION IN SEMICONDUCTOR HETEROSTRUCTURES MODULATED BY RADIO-FREQUENCY ELECTRIC FIELD

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We have observed a strong effect of the radio-frequency (rf) electric field modulated in amplitude on a light reflection in GaAs/AlGaAs heterostructures. This phenomenon is found to be due to the conduction electrons and excitons in different layers of the heterostructure. It may be used as a basis for optical modulation spectroscopy which provides information about electrons, excitons and internal electric fields in semiconductor layers. This kind of spectroscopy can be named as ***radio-frequency modulated reflectance (RMR)*** [1]. Its feature is a very low energy of external action which is required. The heterostructure with two dimensional electron gas or quantum wells is placed between the plates of a capacitor across which the ac voltage is applied with the frequency ~ 20 MHz. One capacitor plate has a hole through which the probing light beam falls on the sample and the reflected beam comes out. The latter is modulated in intensity due to electro-optical effect of the rf electric field. The external rf field causes the free charge carriers to be spatially redistributed in the heterostructure layers. In such a way the internal electric field is changed in heterostructure layers giving rise to a modulation of the dielectric function. The RMR effect is most pronounced in the energy range of size quantization and interband critical points.

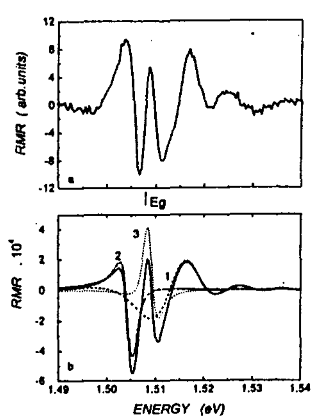

Fig. RMR spectra of GaAs/AlGaAs modulation doped heterostructure in the photon energy range close to the GaAs band gap.
(a) The experiment at 77K, the amplitude of rf electric field ~ $5 \cdot 10^2$ V/cm,
(b) The theory with account of following mechanisms of rf electro-optical modulation shown by dashed lines:
(1) Franz-Keldysh effect, (2) excitons, (3) interband transition near to M_0 critical point.
The full line is the total effect.

1. O.A.Ryabushkin, V.A.Sablikov. JETP Lett., V.67, N.3, (1998) (to be published)

WL33

HELICOPTER LASER DIAL GAS-ANALYSER BASED ON OPO TUNED IN WAVELENGTH RANGE 2,7-3,7 MCM

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The first experiments used OPO for detection methane and sulphur dioxide in real atmosphere conditions had made at the end of seventh's /1/ . But , perhaps , due to usual meaning of OPO emission bandwidth is more then separate gas absorption line width at normal atmospheric conditions , further attempts of practical using of OPO for gas analyse were very rare . In present work results of flight tests of helicopter DIAL gas-analyser based on OPO used for detection of hydrocarbon's presence in real atmosphere conditions are reported .

OPO scheme is optimised traditional one : solid-state pumping laser on $YAlO_3 : Nd^{3+}$, consist of master oscillator with stable thermo-optic compensated resonator , amplifier and OPO itself based on thermo-stabilized $LiNbO_3$ crystal with signal 2,7-3,7 mcm idle wave and 1,5 -1,8 mcm flat resonator . The wavelength tuning is managed by PC with step motor . The full tuning wavelength range from 2,7 mcm up to 3,7 mcm corresponds to 4000 steps of motor . The one step dispersion depends on spectrum region but approximately is equal 0,3 cm^{-1} near three microns region .

DIAL gas-analyser consist of two OPO , transmitter-receiver channel , information processing and managing system based on PC . Real-time information with measurement results is showing on PC monitor and is fixed on PC HD .

Due to flight tests DIAL gas-analyser on board of helicopter MI-8 at main gas pipelines the functional characteristics of laser gas-analyser are following . The operation range of gas-analyser depends on reflective properties of under-layer ground surface and spreads from 150 m up to 1000 m . Concentration sensitivity to methane is 2 ppm , propane - 4 ppm for operation distance 100 m and every-impulse analyse of information with accuracy is about 20 % . According to OPO emission bandwidth there are possibility for separate atmospheric analyse of water , methane , ethane , propane and some other hydrocarbons using representative helicopter DIAL gas-analyser .

/1/ Baumgartner R.A.,Byer R.L. Applied Optics , v.17 , p.3555 (1978) .

WL34

Paper has been withdrawn

WL35

Inversion Procedures for the PFOODR Experimental Data on the Li_2 Molecule

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New techniques are proposed for analyzing the PFOODR[1] experimental data on the $a^3\Pi_u$, $2^3\Pi_g$, $3^3\Sigma_g^+$ and $3^3\Pi_g$ triplet states of the Li_2 molecule. They are: the Inverse Perturbation Approach for determining the repulsive potential from the structured continuum, the WKB nodes method for determining the attractive potential from the same continuum, and the method of the complex two–step fitting for determining the attractive potential from a small set of various experimental data. The high quality of the earlier reported potential energy curves obtained with the "standard" techniques for the $2^3\Pi_g$ and $3^3\Sigma_g^+$ states and the ab initio one for the $a^3\Pi_u$ state have been confirmed. The new function of the electronic transition moment operator for the $3^3\Sigma_g^+ \rightarrow a^3\Pi_u$ transition has been obtained. The new vibrational assignment and the potential function for the $3^3\Pi_g$ state differing from the earlier reported has been determined. This work was supported by the RFBR (grant N 003-96-00035c and 003-96-32797a) and the NNSF of China (grant N 29573110).

[1] Perturbation Facilitated Optical-Optical Double Resonance; see:
Li Li and R. W. Field, J. Phys.Chem. **87** (1983), 3020;
A. Yiannopoulou, K. Urbanski, S. Antonova, A. M. Lyyra, Li Li, T. An, T. J. Whang, B. Ji, X. T. Wang, W. C. Stwalley, T. Leininger and G. -H. Jeung, J. Chem. Phys. **103** (1995) 5898

18:30-20:00 **RED HALL**

WM - Fundamental Aspects of Laser-Matter Interaction II

WM1

THE COMPARATIVE ANALYSIS OF EXACT SOLUTIONS OF ONE AND THREE DIMENSIONAL QUANTUM KINETIC EQUATIONS WITH VELOCITY DEPENDENT COLLISION RATES

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The modern problems of nonlinear spectroscopy and light-induced gas kinetic demands the account of the velocity dependence of collision rates [1]. The investigation of the role of this velocity dependence is impossible without the sufficient progress in the modeling of the collision integrals. The account of the velocity dependence of the collision rates in the collision integral dramatically increases the complexity of quantum kinetic equation [1]. The problem of simplification of 3-dimensional quantum kinetic equation to a much more convenient and easy solvable 1- dimensional quantum kinetic equation is very acute.

We suggest the model, in which for the first time it is possible to analyse the validity of the 1- dimensional Boltzmann equation from rather general point of view. We investigated this problem in details.

The interaction of a monochromatic travelling wave with two levels particles, undergo collisions with the particles of a buffer gas, is considered. The extension of the strong-collision model to the case of velocity- dependent collision rates (the so-called "kangaroo" model [2]) is the basis of our approach.

For the first time, we obtained the analytical solution of the quantum kinetic equations for the general case of arbitrary intensity of the radiation, arbitrary ratio of the homogeneous and Doppler widths and arbitrary mass ratio of the absorbing- and buffer- gas particles.

With the help of these exact solutions of quantum kinetic equations, we calculated the shape of the monochromatic absorption line; the absorption line shape of weak (probe) radiation in the presence of strong monochromatic radiation; the frequency dependence of the light- induced drift velocity.

The comparison of one- and three- dimensional versions of our model reveals the following hierarchy. Namely, the correction cased by velocity dependence of the collision rates is sufficiently larger, than the correction caused by the reduction of three- dimensional to one- dimensional quantum kinetic equation.

We found conditions for the brightest manifestation of the velocity dependence of the collision rates, which occurs in the so-called anomalous light-induced drift. It was proved that one- dimensional collision integral is valid with high accuracy in wide range of problems in the fields of linear and nonlinear spectroscopy, in the light- induced gas kinetic.

References.

1. Rautian S.G. and Shalagin A.M. *Kinetic problems of nonlinear spectroscopy*, Amsterdam: Elsevier, 1991.
2. Brissaud A. and Frisch U., J.Math.Phys, 15,524, 1974.

WM2

LASER-INDUCED PHASE TRANSITIONS OF CARBON UNDER OPTICAL FEEDBACK CONTROL.

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This optical feedback approach describing dynamics of carbon phase transitions under laser pulsed irradiation of graphite targets considers the feedback between velocities of laser melting/evaporation interface movement and melt film thickness. Optical character of the feedback is based on variation of melt film optical features (transmittance, absorbance, reflectance) with melt thickness due to the effect of interference. Basic regimes of laser-induced phase transitions dynamics (steady-state, "transparency wave", explosive evaporation) has been described using the approach with optical constants and evaporation heat of the material studied as main parameters.

Interference of radiation at laser heating of polycrystalline graphite was observed by laser reflectometry as oscillating angle dependence of reflectance. This phenomenon was explained by presence of surface optically "thin" carbon melt film which thickness has been calculated using interference extrema rules for reflection.

Dependencies of liquid film thickness, crater depth, thermoacoustic and recoil pressure amplitudes, vapour composition on laser power density which are usually describing dynamics of carbon laser-induced phase transitions have been determined by laser reflectometry, optoacoustic spectroscopy and time-of-flight mass spectroscopy. Steady-state laser melting and evaporation of carbon was found to take place under laser irradiation with power density of 0.05-0.3 GW/cm2 and characterize by constant liquid film thickness and reflectance, linear relationship between crater depth, thermoacoustic and recoil pressure amplitudes and power density. Explosive evaporation of carbon as hydrodynamic expansion at threshold power density 0.3 GW/cm2 followed by nanodroplets yield has been explained by the optical feedback approach in terms of spinodal decay of the substance.

WM3

Dynamic multiple scattering of laser radiation on light-induced flows of microparticles in suspension

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It is known that small (micron-sized) particles can be accelerated by a powerful laser pulse to considerable velocities (up to 10^6 cm/s). The effect of particle flow on coherence of scattered radiation is enhanced in concentrated suspensions of particles, where the light scattering is substantially multiple. Thus the measurements of the temporal correlation function of multiple-scattered light could provide information on the laser-induced particle flows. This point is of fundamental importance because traditional optical methods of particle flow diagnostics fail in the multiple-scattering regime.

We analyze the possibility of optical diagnostics of laser-induced particle flows in concentrated multiple-scattering suspensions. Various models of laser-induced particle flow are considered. We show that scattered radiation of the accelerating laser beam could give information on the "light-to-particles" impulse transfer, and on the characteristic velocities of the laser-accelerated particles. For instance, a jet of particles is observed in suspension if the incident laser beam is strongly focused. In this case we find the coherence time of backscattered radiation to be $\sim\eta l\lambda/P$, where η is the dynamic viscosity of the suspension, l is the photon transport mean free path, λ is the wavelength of light in the medium, and P is the impulse transfer from the laser beam to particles in a unit time. On the basis of our results we conclude that methods of correlation spectroscopy could be applied for optical diagnostics of laser-induced flows in concentrated suspensions.

WM4

PHOTOINDUCED AMPLIFICATION OF A SUBHARMONIC OF LIGHT AND PHOTOELECTRIC INSTABILITY IN GLASS.

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Illumination glass by two crossed intercoherent beams of basic and double frequencies induces a long-lived spatially periodic modulation of an index of refraction (N-gratings) [1] and modulation of a effective polarizability of the second order (χ^2-gratings) (see the review [2]).

In our work for the first time the amplification of a subharmonic of light in photoinduced gratings analogue of degenerate parametric amplification in quadratically - nonlinear medium is detected. By crossing of basic beam (pumping) and weak beam of the subharmonic (signal) we had recorded the growth of the signal in time up to saturation (photoinduced amplification).

The last phenomenon is directly connected to amplification of gratings by monochromatic light [3]. Such effect results in photoelectric instability - the gratings with small initial amplitudes are grown, with large are relaxed.

In work the results of detail researches of photoinduced amplification (the dependence from pumping intensity, polarizations, phase shift etc.) and photoelectric instability are adduced. Connection between phenomena is established. Physical models of the phenomena taking into account accumulation of electrical charges in glass owing to coherent photogalvanic effect are offered.

References

[1] M.K.Balakirev and V.A.Smirnov, JETP Lett., 61, 537, (1995).

[2] E.M.Dianov, D.S.Starodubov, Kvant.Electron.,22, 419, (1995).

[3] M.K.Balakirev, L.I.Vostrikova, V.A.Smirnov, JETP Lett., 64, (1997).

WM5

TRANSIENT PHENOMENA IN A THIN FILM OF THREE-LEVEL ATOMS UNDER ULTRASHORT-PULSE EXCITATION

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We shall report a theoretical investigation of the dynamics of transmission of an ultrashort light pulse by a thin film consisting of three-level atoms in the Ξ-configuration. It is assumed that photons of the incident pulse with the frequency ω induce multistage transitions between levels $1-2$ (self-frequency $\omega_{12} \approx \omega$) and $2-3$ (self-frequency $\omega_{23} \approx \omega$), giving rise to a dynamic polarization of the medium that determine the optical properties of the film throughout a pulse.

The time evolution of the system is described by a set of differential equations for density matrix components, supplemented by electrodynamic relationships, that follow from the conditions of conservation of the tangential components of the fields at the film boundaries. An analysis of these equations shows that the incident pulse amplitude F_0, the ratio of the corresponding dipole matrix elements $q = |d_{23}|/|d_{12}|$, and the difference between the self-frequencies $\omega_m = |\omega_{23} - \omega_{12}|$ are the bifurcation parameters of the system. The relevant parametric space (F_0, q, ω_m) is splitted into a few regions wherein the character of the transmission by the film is qualitatively different.

For the simplest case of the equal distance configuration ($\omega_m = 0$) we have obtained the bifurcation curves $f_{\pm}(q)$ and exact analytic solutions for the transmitted pulse envelope $F(t)$ when the film is resonantly excited by a rectangular pulse of the amplitude F_0. There is a threshold-like qualitative change in the transmission by the film from almost total reflection of weak incident pulses ($F_0 < f_+(q)$) to oscillatory behavior at high level of excitation ($F_0 > f_+(q)$).

For the case $\omega_m \neq 0$ the time evolution of the system becomes more complex due to arising additional phase modulation of its components with the frequency ω_m. The corresponding bifurcation values of F_0 have been found by us for given values of the parameters q and ω_m using computer simulations. The most interesting transient effects take place when the incident pulse amplitude F_0 is close to its critical value $F_{cr}(q, \omega_m)$. If F_0 exceeds slightly F_{cr}, the film can transform a rectangular pulse either into one soliton-like ultrashort subpulse or into a sequence of several subpulses.

WM6

Polarisabilities of aromatic molecules in the "free-electron" approximation

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In the simplest free-electron model of the aromatic molecules [1], the benzene ring is considered as a rectrangular thoroidal well of height z_0 and infinite, whose inner and outer radii are ρ_1 and ρ_2.

The one-electron Green's function for this system can be derived according to [2]:

$$G(E, \rho, \rho') = \sum_{k=-\infty}^{\infty} \sum_{m=-\infty}^{\infty} g_{km}(E, \rho, \rho') e^{im(\varphi-\varphi')} \sin\left(\frac{kz'\pi}{z_0}\right) \sin\left(\frac{kz\pi}{z_0}\right)$$

$$g_{km}(E, \rho, \rho') = \frac{\mu}{z_0^2 \pi \hbar^2 (e_1 - e_2)} \Big((C_1 J_m(\lambda\rho_<) Y_m(\lambda\rho_>) + C_1 C_2 J_m(\lambda\rho) J_m(\lambda\rho') + C_2 J_m(\lambda\rho_>) Y_m(\lambda\rho_<) + Y_m(\lambda\rho) Y_m(\lambda\rho') \Big)$$

Here J_m, Y_m are the Bessel and Neumann function correspondently; $C_1 = -\frac{Y_m(\lambda\rho_1)}{J_m(\lambda\rho_1)}$, $C_2 = -\frac{Y_m(\lambda\rho_2)}{J_m(\lambda\rho_2)}$, $\rho_< = \min(\rho, \rho')$, $\rho_> = \max(\rho, \rho')$, $\lambda^2 = \frac{2\mu}{\hbar^2}\left(E - \frac{\hbar^2 k}{8 z_0^2 \mu}\right)$, μ is the electron mass, E is the one-electron energy, m is magnetic quantum number, $k = 0, \pm 1, \pm 2 \ldots$

The dynamic polarizability of $|i\rangle$ state (d is the dipole moment)

$$\alpha_{jk}(\omega) = \langle i | d_j G(E^i + \omega\hbar) d_j + d_k G(E^i - \omega\hbar) d_j | i \rangle,$$

calculated at $\rho_1 = 0.1$ Å, $\rho_2 = 2.78$ Å, $z_0 = 0.35$ Å yields the static values $\alpha_{xx}(0) = 94.97$ a.u., $\alpha_{zz}(0) = 52.52$ a.u. while the experimental values [3] are $\alpha_{xx}^{exp}(0) \sim 75.51 \div 84.49$ a.u., $\alpha_{zz}^{exp}(0) \sim 43.2 \div 53.06$ a.u.

[1] R. L. Hummel, K. Ruedenberg, in: *Modern Quantum Chemistry, Academic, N.Y., 1965.*

[2] L. P. Rappoport, B. A. Zon, N. L. Manakov, *Theory of multiphoton processes in atoms, Atomizdat, Moscow, 1978.*

[3] A. N. Vereschagin, *Polarizability of molecules, Nauka, Moscow, 1980.*

WM7

Shock Wave Effect on Emission Spectra of Laser Plasma Induced on the Surface of Solid Targets in Gas Atmosphere.

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A relation between spectral features of laser plasma and ambient gas pressure has been experimentally obtained. The registration of laser plasma emission spectral lines Stark shift [1,2] allowed us to determine electron temperature and electron density without considering the presence of local thermodynamic equilibrium (LTE) in laser plasma [3].

The relations between emission spectral lines intensities, Stark shift, line broadening and ambient gas pressure (helium atmosphere and normal atmosphere) were obtained. The analysis of experimental data allows explanation of the changes in emission spectra by shock wave formation under conditions of gas atmosphere.

It was determined that maximums of emission line intensities had been at different atmospheric pressure values for neutral atoms and ions (Al I, Al II, Al III). Relations between electron temperature, electron density and atmospheric gas pressure were received.

1. *O.A.Bukin, E.A.Sviridenkov.* Письма ЖТФ, 23, 23 (1997).
2. *O.A.Bukin, E.A.Sviridenkov.* Quantum Electronics, 23, 8 (1997).
3. *H.R.Griem.* Plasma spectroscopy. Mc-Graw-Hill, NY, 1964.

WM8

LIGHT CONTROLLING WITH THE HELP OF LIGHT.

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The effect of the resonance conversion of the bulk electromagnetic wave into the surface one, leading to the surface plasmon (SP) excitation and calling the surface plasmon resonance (SPR) is strongly sensitive to the metallic film surface condition. A small change of the dielectric constant of the media near the metal surface on which SP are exciting lead to the catastrophical change of exciting conditions. In the result the modulation of the intensity of the exciting electromagnetic wave takes place. For example, it may be a laser radiation of the visible range.

If a liquid crystal film with spasmodic changing characteristics (such as dielectric constant) during heating above its critical temperature point was deposited onto a metallic film, then dielectric constant of the interface layer may be directly change.

If the sandwich consisting of the metallic and liquid crystal films is illuminated by infrared laser radiation on the side of the liquid crystal film, then visible laser radiation illuminating the sandwich on the side of the metallic film and generating SP after its reflection will have a modulated intensity distribution.

We have calculated parameters which are crucial for the suggested method (dielectric constants and thicknesses of films) and have evaluated some factors influencing on the method sensitivity.

Also we have proposed a scheme of the device allowing to converse the light of one wavelength with the help of another light wavelength.

WM9

TIME DELAYED FOUR WAVE MIXING WITH THIN-FILM CAVITY STRUCTURES

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In recent times, the nonlinear optics of thin-film cavity structures have been attracting much attention. Planar cavity structures of the Fabry-Perot type are an example of the simplest physical systems, allowing the model consideration under conditions of a various physical phenomena - optical bi- and multistability, self-pulsation of radiation, soliton formation under acting of ultrashort light pulses, generation of radiation in lasers, dynamic chaos, etc. On the other hand, there is a practicable interest to similar systems in view of their possible applications in the element basis of optoelectronics.

In the present paper the transmission of sequence of two ultrashort light pulses through the resonant cavity structure are considered. The arising features of the degenerate Time Delayed Four Wave Mixing (TDFWM) or Photon Echo (PE) effects are researched. It is shown that the temporal properties of the PE signals are defined by transient processes connected with the transition to a steady state of the field in the cavity, and by the finite photon lifetime in a cavity [1,2]. In the small area approximation the analytic decisions of the basic system of dynamic equations were obtained. It was shown that one is in many respects similar to the case of the bulk excitation of the solid state resonant medium [3], unlike the case of gaseous resonant medium. Besides, it follows from these considerations that the dynamic efficiency in a holographic formation of nonstationary images can substantially exceed the analogous quantity in the case of bulk excitation of the resonant medium.

In the case of arbitrary areas of exciting pulses the problem was numerically decided. It was also shown that the behavior of the resonant system has an oscillator character and reminds the phenomenon of multiple PE, observed in the gaseous resonant media.

The possible practicable applications of noticed features is discussed.

REFERENCES

1. S.M.Zakharov. JETP, 1995, **81**(3), 452-458.
2. V.A.Goryachev, S.M.Zakharov. Quantum Electronics, 1997, 27(3), 245-248.
3. S.M.Zakharov, E.A.Manykin. JETP, 1986, 64(4), 761-768.

WM10

QUASICLASSICAL LIMIT OF THE QUADRATIC SUSCEPTIBILITY

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SUMMARY

The general properties of the quadratic susceptibility β of an autonomous Hamiltonian system to the external harmonic perturbation with the frequency ω are studied in the quasiclassical limit $\hbar \to 0$.

The general quantum expression for the $\beta(\omega)$ is given by the sum of terms dependent on matrix elements of the coordinate x_{nm} and the transition frequencies ω_{nm}, multiplied by the factor $\hbar^{-2}$. Therefore the quasiclassical limit of the expression is determined by the terms of the first and second order in $\hbar$-expansion of x_{nm} and ω_{nm}. The former can be obtained from symmetry and transitivity considerations and in the quasiclassical limit yield the exact form of the classical linear susceptibility [1]. The terms of the second order in $\hbar$ can be derived by Maslov's technique [2]. The final expression connects $\beta(\omega)$ of the microcanonical ensemble to the volume of the energy surface and the triple correlators of the Fourier - amplitudes of the coordinates and their derivatives in energy. It is applicable to the systems with regular or chaotic motion in the classical limit.

If in the classical limit the motion of the system is chaotic, then by definition the fundamental set of solutions of the system of linearised equations for the response includes at least one function that increases with time exponentially, the exponent being the positive Lyapunov exponent. This can lead to the conclusion that the susceptibilities of chaotic system are directly connected to the magnitude of the positive Lyapunov exponent [3]. Starting from the quantum expression it can be seen that in the quasiclassical limit the exponentially growing contribution to the response cancels out, thus excluding the explicit dependence of the susceptibility on the degree of instability of motion.

References

[1] A.V. Gaponov, M.I. Petelin, and V.K. Yulpatov. Radiophys. and Quantum Electr. 10 (1967) 794.
[2] V.P. Maslov. Usp. Mat. Nauk 15 (1960) 220
[3] S. Mukamel, V. Khidekel, and V. Chernyak. Phys. Rev. E 53 (1996) R1

WM11

NONLINEAR CRITICAL OPALESCENCE IN THE VICINITY OF STRUCTURAL PHASE TRANSITION IN $SrTiO_3$

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The fluctuations of the order parameter in the vicinity of a structural phase transition, which can accompany a critical behavior of crystal parameters, give rise to new optical phenomena. In linear optics the fluctuations of the dielectric permittivity cause light scattering at the fundamental frequency (Rayleigh scattering), which is known as critical opalescence. In this paper we consider light scattering at the double frequency (hyper-Rayleigh scattering or HRS) due to the fluctuations of the order parameter, called nonlinear opalescence (NCO).

We report here the observation of NCO in a single crystal of $SrTiO_3$ near the *m3m* to *4/mmm* phase transition at T_c= 105 K. We studied the temperature dependences of the SHG intensity generated by the output of a Ti:sapphire laser. In the vicinity of T_c a local maximum of the HRS is observed, which appears as a shoulder on a general increase of the SHG intensity (the latter is caused by critical temperature dependences of the linear and nonlinear susceptibilities of $SrTiO_3$ at the low-temperature critical point). The local maximum observed is attributed to NCO at a centrosymmetric- to-centrosymmetric phase transition. The NCO mechanism is related to the fluctuations of the second-order quadrupole susceptibility. These fluctuations can be either thermal (dynamic) or static, caused by defects giving rise to a field conjugated to the order parameter of the phase transition. Generally this can be considered as a local braking of the crystal the inversion symmetry near T_c.

WM12

EXCITON ABSORPTION AND GAIN BANDS IN SEMICONDUCTORS COHERENTLY POLARIZED BY LASER RADIATION

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The exciton absorption and emission bands are considered in the presence of the Bose-Einstein condensation (BEC) of excitons induced by a coherent laser radiation. The coherent macroscopic polarization of the crystal produced by the laser radiation is treated as a virtual BEC of excitons. The energy spectrum of the elementary excitations and the probabilities of the quantum transitions from the ground state of the crystal to the quasiexciton state are shown to depend strongly on the detuning $\tilde{\Delta}$ between the exciton level and the energy of the laser photon. The exciton absorption and gain bands are situated correspondingly on high and low energy sides with regard to the laser frequency. Their lineshapes consist of the peaks and broad wings. The intensity of the absorption band is determined by the factor $(1 + n^{ex}_{\mathbf{q}})$, where $n^{ex}_{\mathbf{q}}$ is the distribution function of the nonequilibrium incoherent excitons. The intensity of the luminescence band is proportional to the factor $n^{ex}_{\mathbf{q}}$. The anisotropy of the bands is analysed for three different orientations of observation. When the frequency of laser radiation coincides with the renormalized exciton level the induced BEC of excitons transforms into the real but nonequilibrium BEC. The occupation numbers $n^{ex}_{\mathbf{k}_0+\mathbf{k}}$ diverge at $\mathbf{k} = 0$. There appears a pronounced difference between the occupation numbers of scattered excitons $n^{ex}_{\mathbf{q}}$ if $\mathbf{q} \to \mathbf{k}_0$ and if $\mathbf{q} \to -\mathbf{k}_0$. This leads to the anisotropy of the absorption and emission probabilities. At negative values $\tilde{\Delta}$, the instability occurs in the system. The occupation numbers $n^{ex}_{\mathbf{q}}$ become infinite in the regions of k-space where the energy spectrum is complex. In these regions, the generation of new waves due to the induced exciton combinational scattering takes place. The damping of the exciton levels is taken into account. It leads to the existence of the real and imaginary parts of the energy spectrum of the elementary excitations in the presence of laser radiation and to finite values of the nonequilibrium occupation numbers $n^{ex}_{\mathbf{q}}$ even in the wave vector regions where they were infinite in the absence of the damping. This fact permitted to obtain regular expression for the exciton absorption and gain bands at arbitrary frequency detunings $\tilde{\Delta}$.

WM13

THE SCHWARZ-HORA EFFECT: PRESENT-DAY SITUATION

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The Schwarz-Hora effect [1,2], observed under attempts to modulate an electron beam at a laser frequency, was discussed extensively in the literature in the early 1970s. However, since 1972 no reports on the results of further attempts to repeat those experiments in other groups have appeared, while the failures of the initial such attempts have been explained by Schwarz in Ref. [3].

The analysis of the literature shows there are the unresolved up to now contradictions between the theory and the Schwarz experiments:

1. *The radiation intensity.* The calculated power of the coherent emission of light at the laser frequency turns out to be at least 10^3 times smaller than the observed intensity.

2. *The dependence on the electron current.* The experimental photographs allow to affirm that the intensity of the Schwarz-Hora radiation is linear on an electron beam current. The quantum-mechanical treatment leads to the quadratic dependence.

3. *Polarization angle dependence.* The observed intensity of the radiation depends very strongly on the laser light polarization. A theoretical explanation of such dependence is absent.

4. *Initial phase of the spatial beating.* The experiments indicate that there must be the maximum of the radiation intensity at the dielectric film surface. The quantum models predict the minimum.

5. *The spatial period.* The discrepancy of more than 10% between the experimental and theoretical results exists for the period of the spatial beating of the Schwarz-Hora radiation.

These contradictions allow to conclude that we have not the adequate theory for interpretation of the Schwarz-Hora effect. New experimental information is necessary to clear up the situation.

1. H. Schwarz and H. Hora, Appl. Phys. Lett. **15**, 349 (1969).
2. H. Schwarz, Trans. NY Acad. Sci. **33**, 150 (1971).
3. H. Schwarz, Appl. Phys. Lett. **20**, 148 (1972).

WM14

Laser-induced hydrodynamic effects in liquids and liquid crystals

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Abstract. A linear polarized Ar^{3+} laser beam passing through the polarizer, horizontal flat capillary, analyzer system and fall into NLC volume. Due to thermal expansion arise NLC motion, with induced molecular reorientation. For register hysteresis appearance used mechanism with reverse communication. And we have observed convective motions in the isotropic liquid.

1. The effect of nematic liquid crystal (NLC) director reorientation due to the light -induced hydrodynamic flow caused by the absorption of laser radiation of rather moderate power (about 1mW) theoretically was predicted originally in Ref.1. Later this mechanism of reorientation was applied to explanation of experimental data with microcapillaries in porous media in Ref.2. In the presented work we have observed and investigated experimentally the following process. The absorbed light energy heats the NLC causing its thermal expansion. After that a pressure gradient results in a Poiseuille flow of the NLC. Later, molecules reorient due to the strong coupling of hydrodynamic and orientational motions in the NLC. It has been found that there is hysteresis in the NLC transmission dependence on the intensity of the radiation giving rise to light-induced hydrodynamic reorientation. The conditions are realized in NLC when, apart of the hysteresis characteristics, determining the optical bistability in the system, the instabilities arise leading to the temporal oscillations and stochastisity in a certain area of the values of the controlling parameters.
2. In the experiment the Argon-Ion laser radiation (the wavelength 5145 A) was absorbed by NLC placed in a heat-insulated vessel which was in communication through a plain capillary with another vessel with free surface. The absorption of the radiation leads to the certain increase of the temperature and to the volume expansion of NLC. The last caused the hydrodynamic motion and therefore the NLC director reorientation in the capillary. The detection of the director reorientation was carried out by the Ar^{3+} laser radiation, which was normally directed to the walls of the capillary and after passing through it was incident to the analyzer, the optical axis of the last being crossed with the respect to the initial polarization of the probe beam. To provide a sufficient absorption a dye (Rodamin 6G) was added to NLC (5CB). The absorption coefficient of the compound for the wavelenght of the pump radiation was $0.2cm^{-1}$.
3. We have observed convective motions in the isotropic liquid with one free surface induced by light with a spatially periodic intensity structure. We study the competition of two mechanisms for excitation of convective motions: gravitational and thermocapillar.

1. R.S.Akopyan, B.Ya.Zeldovich, N.V.Tabiryan. *Opt.Spectrosc.*(USSR) 1988, 65 (3), pp.344-346.
2. R.S.Akopyan, N.V.Tabiryan, T.Tschudi. *Phys.Rev.E.*, 1994, 49 (4), pp.3143-3149.

WM15

Nonlinear response of photorefractive lithium tantalate and niobate at sound frequencies

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It is well known that in photorefractive lithium tantalate and niobate, photoinduced light scattering (PHILS) and holographic-type parametric scattering (HTPS) [1] are possible. In PHILS light is scattered by a set of random holographic gratings, and HTPS is scattering by a subset of these gratings satisfying the four-wave phase matching condition. The characteristic time of recording such gratings is defined by the Maxwell time $\tau_m \sim \varepsilon/4\pi\sigma$ (here ε is the dielectric function and σ the electric conductivity of the crystal), which can vary in $LiNbO_3$ and $LiTaO_3$ from some minutes to many hours depending on the pump intensity.

In our experiment we compare the correlation functions and fluctuation spectra for the pump intensity modulated at frequencies f~100 Hz, and for the intensity of PHILS or PHS in $LiTaO_3$:Cu and $LiNbO_3$:Cu [2]. We observed (Fig.1) that in the scattered light intensity fluctuations are amplified. As far as we know, there are no models which can explain this amplification of oscillations at such frequencies in photorefractive light scattering.

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[1] S.Odoulov, K.Belabaev, I.Kiseleva, Optics Letters **10**, 31 (1985)
[2] P.A.Prudkovskii, O.V.Skugarevskii, A.N.Penin, JETP, **85**, 812 (1997)

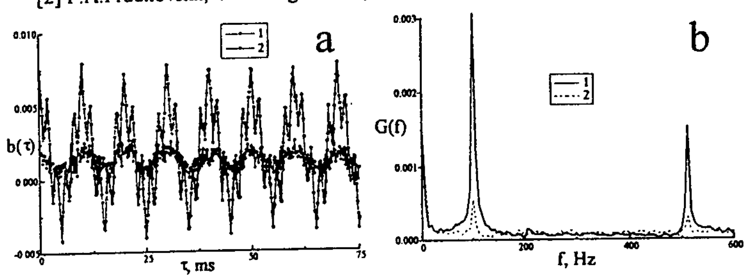

Fig.1. Correlation functions (a) and fluctuation spectra (b) for the pump intensity (1) and the intensity of HTPS in $LiTaO_3$:Cu (2).

WM16

Instability of high-power electromagnetic field in nonabsorbing microinclusions in transparent dielectric

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SUMMARY

There are considered models to describe abrupt local increasing of electric-field amplitude in transparent dielectric due to light-induced resonances in nonabsorbing inclusions They are based on self-induced formation of unstable field structure in dielectric microinclusions. The presented results show that small (its radius is about wavelength) transparent inclusion can cause large field amplification. We consider two models: 1) model of laser-radiation behavior in inclusion of near-resonant size which can concentrate laser field due to light-induced formation of microinclusion's eigenmodes; 2) model in which small local enhancement of the field amplitude is initiated by low-absorbing spherical or cylinder inclusion which size is less than radiation wavelength, so that resonant field mode cannot be formed in the inclusion. It is shown that both cases can result in increasing of field amplitude which is referred to as field instability.

Possibility for field instability to arise is estimated making use of model of diffraction of high-amplitude plane wave on sphere and cylinder which radii are about radiation wavelength. Field instability is shown to be threshold-like phenomenon. There are estimated threshold amplitude of incident wave and field amplification in the microsphere and cylinder. Presented results of computer modding of evolution of high-power laser field in dielectric cylinder confirm the presented ideas. Possible laser-induced processes in transparent dielectric are discussed.

WM17

STIMULATED MANDELSHTAM-BRILLOUIN SCATTERING IN A DOUBLE CRITICAL POINT MIXTURE

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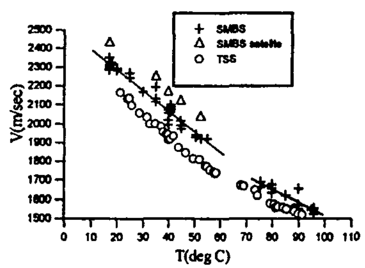
Hypersound velocity and its temperature dependence in gvayacol-glicerol mixture were investigated by means of Stimulated Mandelshtam-Brillouin Spectroscopy (SMBS). This mixture is remarkable for being homogeneous for all temperatures but the vicinity of $T_c \approx 62^0$C. It is prudent to investigate characteristics of this matter and their difference upper and lower this point. Velocity behavior in this realm, measured by Thermal Scattering Spectroscopy (TSS) deviates significantly from acoustic datum indicating the existence of structural jump. High pressure and electrical field in laser focus were likly to stimulate this structural modification but reveals only in Rayleigh Scattering (RS), having nonshifted frequency. The problems of SMBS and RS concurring are discussed to be inclined to SMBS part. The temperature dependence of sound velocity given by SMBS experiments is compared to TSS results on the picture.



Temperature coefficients $\frac{\partial V}{\partial T}$ for SMBS and TSS data are similar within the experimental accuracy and are twice as large for $T<T_c$ to be compared with $T>T_c$ values. It points out that the intensities about 10^9w/cm^2 are not enough to overcome the energy of microcomplex occuring at a lower side of T_c. The velocity value V for SMBS is adequate to about ½ ν_{fwhm} additional stokes shift that those measured by TSS. Previously unknown weak satellite another ½ν_{fwhm} stokes shifted was detected. Those shifts are interpreted to be due to the new Termal -SMBS phenomena based on multyphoton absorption of visual light for temperatures near the critical point of the substance. Necessary estimations of the effect are made to explain the spectra attained.

WM18

Hypersound pulses in semiconductors: photoexcitation, propagation and photodetection

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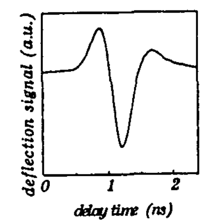
The highly sensitive picosecond photodeflection spectroscopy technique which combines the advantages of precise cw photodetection and picosecond temporal resolution has been developed. We have applied the developed technique for investigation of excitation and propagation of hypersonic laser-induced pulses in thin monocrystalline semiconductor plates. In our experiments with Ge we have observed transient back surface displacements produced by picosecond optical excitation of the front surface.

A mode-locked cw-pumped Nd:YAG laser ($\lambda = 1064, 532$ nm) producing $\sim 70-100$ ps pulses with 100 MHz repetition rate was employed as the optical source for both hypersound photoexcitation and photodetection. The deflection signal corresponding to the surface displacement of $\sim$10 pm as a function of the pump-probe delay is presented in the figure.



This signal was observed at the propagation path of ~ 500 μm and its shape contains the information about both hypersound photoexcitation mechanism and the features of propagation, i.e. diffraction and absorption.

It has been established experimentally that the hypersound pulses are photoexcitated in Ge via a not-thermal mechanism. The photoinduced electron-hole plasma ($N \simeq 5 \times 10^{18}$ cm^{-3}) is a source of elastic stress according to the electron-deformation mechanism of sound photoexcitation [1]. The influence of propagation effects (acoustical diffraction and absorption, phonon focusing) on the shape of observed hypersound pulses has been revealed. The contributions of surface acoustical waves, surface recombination and sample inhomogeneity to the observed signal are evaluated. The spectroscopic applications of the transient hypersound spectroscopy method are discussed.

1. S.A. Akhmanov and V.E. Gusev, Uspekhi Fiz. Nauk **163**, 3 (1992).

WM19

FAST WAVES OF POINT DEFECT FORMATION AND AMORPHIZATION IN LASER-EXCITED SEMICONDUCTORS AND DIELECTRICS

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Point defect formation wave (DFW), ignited and propagated in laser-excited semiconductors (and dielectrics) with velocity of order of sound velocity is investigated theoretically and experimentally. DFW model is as follows. The absorption of light quanta results in generation of electron-hole pairs. Near initially present defect the localization of a free hole occurs with subsequent capturing of a free electron. The localized e-h pair recombines with the energy released being spent on formation of a new point defect. The cycling recurrence of above processes leads to propagation of the process of point defect generation with the velocity V(I) depending on laser intensity I. Thus local point defect concentration is switched from zero to a high value.

The nonlinear "diffusion" equation for the DFW, similar to combustion front equation, is derived and solved. The DFW shape, velocity, threshold intensity of ignition and maximum value of defect concentration generated are determined analytically. In regime of high intensities, controlled by the Auger recombination (picosecond pulses), defect concentration exceeds the critical concentration of amorphization so that the DFW is accompanied by amorphization wave. In the case of low intensities (nanosecond pulses) defect generation due to DFW occurs without structural transformation.

The DFW theory is shown to well describe known dependencies of the modified *crystalline silicon surface* area on the number of picosecond visible laser pulses as well as dependency of threshold number of pulses to induce damage on pulse intensity.

The experiments with nanosecond pulse train excitation of c-Si were performed and similar area dependency was obtained and described by the DFW theory. Raman spectroscopy detected no structural change inside the illuminated region seen in optical and electron microscope as an area with modified contrast.

WM20

Classical theory for alignment of molecules in laser field

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Recently, ionisation dissociation of molecules has been actively investigated in laser field with the intensity $\leq 10^{16}\,\mathrm{W/cm^2}$. In that experiments, one ore more electrons are detached by the radiation from neutral molecules kept in gaseous phase. It leads to non-stability of the residual ion and to its decay on two ore more fragments. The study of angular distribution of the outgoing fragments show that before the dissociation the molecules are aligned in a direction parallel or perpendicular to the electric vector of the linearly polarised laser wave. Unlike the well-studied optical Kerr effect, in this case the molecules are aligned in a very short time, not longer than the laser pulse duration which is about $\sim 100\,$fsec.

Since the intermolecular collisions can be neglected during such short times, the alignment can be due only to induced Raman scattering of laser radiation which is accompanied by transitions between the rotational molecular states. In terms of classical mechanics this model corresponds to a rotator moving in a high-frequency ac field. The interaction of the rotator with the field is due to the dynamical polarisability of the rotator. Depending on which component (parallel or perpendicular one) of the polarisability tensor is greater, the rotator axis is aligned in the direction parallel or perpendicular to the electric vector respectively.

In the present work this problem is solved both numerically and analytically. The analytic solution is possible for high-intensity laser pulses when the duration of *the laser pulse is much longer than the period of forced vibrations of the rotator axis.* These vibrations are due to interaction of the molecule with the radiation. In this case the solution can be given in framework of the adiabatic approximation used in classical theory of vibration. Basing the analytic solution, the width of the angular distribution function of the rotator axis is shown to depend upon the intensity of the laser radiation according to power low with the exponent $-1/4$.

WM21

LOCAL FIELDS IN MESO- AND MICRO- STRUCTURES OF TWO-COMPONENT MEDIA AS FACTORS FOR CALCULATION OF LINEAR AND NONLINEAR SUSCEPTIBILITIES

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The unique known Lorentz/s microscopic consideration of the heterogeneous dielectrics is based on the identity of the local fields acting on the constituents and is valid only for media with isotropic microstructures. The result has a form of simple summation of the components/ contributions. We apply generalized method of integral equations [1] to find the difference of local fields acting on the components and calculate the optical properties of a regular two-component cristalline medium. The dielectric permittivity $\hat{\epsilon}$ and the local field factors $\hat{f}_{p1}$, $\hat{f}_{p2}$ for the nonlinear susceptibilities are found as functions of thepolarizabilities $\hat{\alpha}_1$, $\hat{\alpha}_2$, and densities N_1, N_2 of the components as well as lattice's geometry (uniteless tensors $\hat{\gamma}$, $\hat{\gamma}_l$):

$$\hat{\epsilon} - 1 = 4\pi N\hat{\alpha}_1 \cdot \hat{f}_{p1} + 4\pi N\hat{\alpha}_2 \cdot \hat{f}_{p2}$$

$$\hat{f}_{p1} = \{1 - (\tfrac{8\pi}{3} + \hat{\gamma}_l + \hat{\gamma}) \cdot N_1\hat{\alpha}_1 - (\tfrac{4\pi}{3} + \hat{\gamma}_l) \cdot [1 + (\hat{\gamma}_l - \hat{\gamma}) \cdot N_2\hat{\alpha}_2]^{-1} \cdot (N_1\hat{\alpha}_1 - N_2\hat{\alpha}_2)\}^{-1}$$

(and, respectively, for $\hat{f}_{p2}$). The macroscopic nonlinear polarization is determined now by an entirely different combination of the local field factors then the linear polarization . Some special cases of crystalline lattices geometry as well as the emergence of spatial dispersion due to the medium's discreteness are discussed.

1. A.V.Ghiner, G.I.Surdutovich, Phys. Rev. 49A, 1313 (1994), 56E, 6123 (1997).

WM22

SLOW WAVE OF REFRACTION CHANGE IN SOLIDS: EXPERIMENTAL AND THEORETICAL STUDY OF SOLITONIC MECHANISM

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In series of experiments, including [1,2], a solitonic wave of optical refraction change (ORC) in crystals and glasses was investigated. The ORC is excited by the IR laser pulse (λ=5, 10 or 20μ, diameter of focal spot ~ 1mm) after exceeding threshold and has the following solitary wave features: 1) the ORC pulse propagates with nearly constant velocity v of the order of 1 cm/s; 2) the ORC can travel a long distance (of order of centimeter) without changing its shape. These ORC characteristics were described in the work [3] on the base of a new model of slow nonequilibrium defect recombination wave (DRW). The present work was undertaken to check whether the DRW-theory [3] can describe correctly the temperature dependence of the ORC velocity. The dependence v=v(T) was measured for crystalline Ge and for amprphous material (SiO_2). In addition we present v(T) dependence for 3 polycrystalline HTSC samples (YBaCuO, NdCeCuO and LaSrCuO) from [4]. The comparison of obtained experimental results with theoretical predictions shows that the DRW mechanism [3] can describe two qualitatively different types of v=v(T) dependencies observed. This work was sponsored by RFBR (Russia), project 97-02-17954.

1. E.M.Kudriavtsev, S.D.Zotov, V.V.Krivov, M.Autric, Physica C, 1994, v.**234-240**, 1439-1440.
2. S.D. Zotov, O.M. Ivanenko, V.V. Krivov, E.M. Kudriavtsev, B.G. Makeev, K.V. Mitsen, Yu.I. Rybalko, Quantum Elektronics, 1996, v.**26**, No 8, 706-709.
3. V.I.Emel'yanov, Laser Physics, 1997, v.7, N°2, 455-460.
4. E.M.Kudriavtsev, S.D.Zotov, V.V.Krivov, M.Autric, Physica C, 1997, v.**282-287**,1145-1146.

WM23

PULSE LASER-BEAM INDUCED INSTANTANEOUS PROFILES OF THE LOCAL QUASI-STATIC DEFORMATIONS ON THE REAL GERMANIUM SURFACES

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One of important photoacoustic phenomena which results due to pulsed laser-matter interaction is generation of the quasi-staticτ surface deformations of solids [1]. On the micrometer space-scale it is possible to detect experimentally instantaneous profiles of shear deformations and subnanometer normal displacements of surfaces using some novel modifications of the conventional laser probe-beam deflection technique [2].

For metals such profiles and specific regimes of pulsed deformations were experimentally and theoretically investigated recently [3,4]. Laser probing of the local deformation profiles on the real semiconductor surfaces - is the aim of the present work.

Two kinds of germanium samples have been used. The first one - high resistively plates with chemically etched «real» [5] surface having relatively low surface recombination velocity S and relatively slow (with respect to the laser pulse-width) effective carrier lifetimes.The second one-«poor» surface of germanium with high values of S and small τ.

We find, that inside the specific time-intervals (only) measured deformation (and displacement) profiles on the «real» germanium surfaces were some more wider than that on the «poor» surface one. At relatively small and large time-moments we couldn't distinguish the corresponding differences. For «poor» surface the shapes of profiles were similar to the metal case. We think, that experimentally observed effect of selective (on time-scale) widening of the space deformation profiles is due to the theoretically-known phenomena of relatively slow heat generation inside the semiconductor subsurface «volume» during the processes of diffusion, recombination and capture of electrons and holes being pulsed photoinduced [6].

LITERATURE

[1] Gusev V .E., Karabutov A.A. Laser Optoacoustics. Moscow (1991). P.258-293.
[2] Vintsents S.V.,Dmitriev S.G. Russian J.of Technical Physics (1997),V.67, N2, P.105.
[3] Vintsents S.V. et. al. Russian J. of Solid-State Physics (1996), V.38, N4, P.993-1003.
[4] Vintsents S.V. et. al. Russian J. of Solid-State Physics (1997), V.39, N12, P.2223.
[5] Novototskii-Vlasov Yu.Ph. Proceedings of PhIAN SSSR, V.48 (1969).
[6] Vorob'ev Yu.V. et.al. Ukraine J.of Physics (1981), V.26, N2, P.276-282.

WM24

KINETICS AND INSTANTANEOUS PROFILES OF QUASI-STATIC ELASTIC DEFORMATIONS AND DISPLACEMENTS OF METAL SURFACES INDUCED ON THE MICROMETER SPACE-SCALE BY A PULSED LASER BEAM

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Using some novel modifications of the measurement procedure with conventional laser probe-beam deflection technique [1], we detect on the micrometer ($r \sim$ 1- 100 μm) space-scale for metal surfaces instantaneous (for $t \sim 0{,}1\text{-}10\,\mu s$) profiles of the shear surface ($z = 0$) deformations $\partial Uz / \partial r\,(r)$ and normal surface displacements $Uz\,(r)$, which have the subnanometer-range amplitudes and being locally induced by a pulsed laser beam.

The time-delay effects of surface quasi-static deformation (and displacement) kinetics with respect to the pulses of heat generation in metals were obtained experimentally and analyzed theoretically [2]. Specific quasi-one-dimensional regime of the pulse laser-induced surface thermo-deformations and displacements have been recently investigated using the novel space-profile approach [3].

Correlation's between surface deformation amplitudes (or regimes of displacement kinetics) and some low-threshold (non-thermal) processes in metals and semiconductors (near-surface damages or point-defect generation) is considered in connection with the method advantages.

LITERATURE

[1].Vintsents S.V., Dmitriev S.G. Russian J. of Technical Physics (1997),V.67,N2,P.105-109.
[2].Vintsents S.V., Dmitriev S.G., Shagimuratov O.G. Russian J. of Solid - State Physics (1996), V.38, N4, P.993-1003.
[3].Vintsents S.V., Dmitriev S.G., Spiridonov K.I. Russian J. of Solid - State Physics (1997), V.39, N12, P.2223-2228.

WM25

Observation of coherent population and polarization changes on Raman-active transition due to two-color pulse excitation.

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Coherent optical excitation modifies medium properties driving atoms or molecules into definite energy level. In that connection a short excitation (in the relaxation time scale) by means of resonant pulse excitation is most appropriate. Temporal evolu-tion of the two-level transition under investigation is characterized by regular oscil-lations of population difference and polarization (optical nutations). Frequency of the oscillations depends on matrix element (or scattering cross section) and exciting pulse intensity. Optical nutations have been many times observed at dipole-active transitions but analogous experiments at Raman-active transitions have not been realized.

Fig.1. Dependences of third harmonic energy $W_{3\omega}$ (-·-·-) and anti-Stokes signal energy W_a(-·-·-) on the delay time between pumping and probing pulses.

In this paper coherent changes of population and free polarization on Raman-active transition $6P_{1/2}$-$6P_{3/2}$ of thallium atoms due to two-color pulse excitation have been experimentally observed. During exciting pulse action with sufficiently high energy they go through at least one period of nutation. Population of the upper level was monitored by probing pulse third harmonic generation. And free polarization was controlled by probing pulse anti-Stokes scattering.

The transition was excited by a couple of pulses of dye-laser and of master oscillator, with wavelengths of 582nm and 1064nm correspondingly and with pulse duration of 30ps. Exciting pulse energies could be increased up to 1.5mJ (dye-laser) and 2.5mJ (master oscillator). To make spatial fields distribution more homogeneous the experiments were conducted with collimated beams.

Starting from the upper level third harmonic generation process is near resonant with dipole-active transition $6P_{3/2}$-$7D_{5/2}$, that is why the efficiency increases by several orders of magnitude. Beam polarization of exciting and probing pulses is crossed. In Fig.1 dependence of third harmonic signal on delay time between exciting and probing pulses is shown. After the excitation the signal exceeds the initial level by 2.5 orders of magnitude and remains almost constant in the whole range of delay times, that corresponds to long enough time T_1 of metastable level $6P_{3/2}$. In the same figure the coherent pulse response, temporal dependence of anti-Stokes scattering of 532nm probing pulse is shown. The dependencies of third harmonic (a) and anti-Stokes scattering (b) signals on exciting pulses energy production are shown in Fig.2. In both cases probing pulses were delayed by fixed time (~200ps, see arrow in Fig.1). The character of the initial part of the dependences corresponds to the first period of population and free polarization oscillations. Then the dependences became smooth due to growing effect of integration over the beam cross profile.

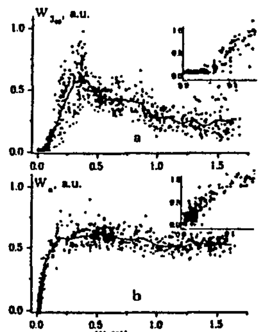

Fig.2. Dependences of third harmonic (a) and anti-Stokes (b) signals on product of pumping energies. The begining parts of the dependences are showing in the insets.

The work was supported by Russian Foundation for Basic Research (96-02-18837).

WM26

OBSERVATION OF NONLINEAR GYROTROPY OF SILVER COLLOID SOLUTION

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The polarization-affecting phenomena in isotropic materials have been extensively studied (see [1, 2] and references therein). The nonlinear optical activity due to the local and nonlocal third-order nonlinearities have been observed in a cubic crystal [1]. It is known that a role of nonlocal effects grows with an increasing of a size of a particle interacted with optical field. Therefore it is interesting to study the nonlocal effects in fractal colloid aggregates. So, optical properties of silver aggregates are determined by dipolar modes, localized in resonance domains with an increasingly larger size ($a \sim 20 \div 100$ nm) with a tuning of the light wavelength to the blue range [3].

We report on, to our knowledge, the first observation of nonlinear gyrotropy of the aggregated colloidal silver solution. In experiments, we used the pump-probe beams configuration with the pulsed laser source at $\lambda = 0.532$ μm and $\tau = 10$ ns.

It was detected the intensity-dependent rotation of the polarization plane when the pump and the probe waves having the same linear polarization pass through the 3-mm-thick cell with aggregated silver colloid solution, containing polymer molecules. While the pump intensity $I_p \leq 1$ MW/cm^2, the angle of rotation $\alpha = gI_pl$, where $g \approx 10^{-2}$ rad·cm/MW, l is the cell thickness. Increasing I_p up to 10 MW/cm^2 made the rotation angle much less dependent of I_p. According to [2], when pump and probe waves have the same polarizations, the nonlinear gyrotropy is caused by the nonlocality of the medium's optical response. Found from our experiments value of nonlocal cubic susceptibility $\Gamma^{(3)} \sim 10^{-16}$ esu fits in well with the estimation $\Gamma^{(3)} \sim a\chi^{(3)} \approx 5 \cdot 10^{-16}$ esu, where $\chi^{(3)} \sim 10^{-10}$ esu is the local cubic susceptibility and $a \sim 5 \cdot 10^{-6}$ cm is the size of the resonant domain for our colloid at $\lambda = 0.532$ μm.

The nonlinear gyrotropy was not found in the cases of nonaggregated silver colloid, polymer solution without silver particles, and aggregated colloid solution without polymer.

References

[1] S.A.Ahmanov, N.I. Zheludev, R.S. Zadoyan. [In Russian: ZhETF **91**, 984 (1986)]

[2] S.V. Popov, Yu.P. Svirko, N.I. Zheludev. JOSA B **13**, 2729 (1996)

[3] V.P. Safonov, V.M. Shalaev, V.A. Markel, et al. Phys. Rev. Lett. **80**, No. 5, 1102 (1998)

WM27

On The Scaling For Values of Electronic Nonlinear Susceptibilities In Organic Polymers

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Presently much attention is given by the researchers to the nonlinear characteristics of optically transparent polymers (OTP) /1/. The value of their nonlinear susceptibility (NS) is the principal parameter which define the efficiency and the competitivity of OTP based nonlinear optical devises. The new simple and reliable method for selection OTP with enhanced electronic NSs is suggested in this work.

It was shown in /2/ that the value of electronic third-order NS in condensed material uniquely defined by its band gap energy $E_g = \hbar\omega_g$ (in another words it is the frequency of violet(V)-side border of material transmittance)

$$\chi_e^{(3)}[\text{esu}] \cong 3\cdot10^{-11}/E_g^4[\text{eV}] \cong 3\cdot10^{-34}\,N/E_g^4[\text{eV}]\,. \qquad (1)$$

It's found that the available experimental data on appropriate $\chi_e^{(3)}$ with simultaneously registered frequencies of V-side borders in the solid OTP /1/ appear to fit well with the scaling (1) as well as those one in optically transparent condensed materials (liquid organic and solid inorganic dielectrics, semiconductors) /2/. In case when OTP is a composition of a set of i monomers with the different values of E_g^i, and their relative concentrations are N^i/N, the value of $\chi_e^{(3)}$ may be estimated with the help of

$$\chi_e^{(3)}[\text{esu}] \cong 3\cdot10^{-34}\sum_i N^i\left(E_g^i[\text{eV}]\right)^{-4}. \qquad (2)$$

Basing on the approach analogous that used for calculation $\chi_e^{(3)}$/2/, it is obtained for $\chi_e^{(2)}$ in noncentrosymmetric materials in low frequency limit ($\omega_g \gg \omega$, 2ω)

$$\chi_e^{(2)} \cong \nu' N e x_0^2/m\omega_g^2 \approx 2\cdot10^{-29}\,\nu'\,N/E_g^2\,, \qquad (3)$$

which gives good fit with experimental data in materials with E_g from ~0.2 (Te) till ~0.7 eV (SiO_2) /13/ in case if $\nu' = 0.05 \div 0.1$. There is no reasons that the scaling (3) will not be valid for OTP.

1. Materials for Nonlinear Optics. Technical digest of 11[th] Topical Meeting of the European Optical Society, Capri(Italy), July 8-12, 1997.
2. V.I.Kovalev, Bull. of RAS, Physics, 60, 908 (1996).

WM28

Nonlinear effects in Faraday rotation and optical absorption in the magnetic semiconductor $CdCr_2Se_4$

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Influence of incident radiation power (P) on the Faraday rotation and the absorption coefficient of circularly polarized light (α) of $CdCr_2Se_4$ single crystals in the energy range of absorption edge at some temperatures above and below Curie's temperature (130K) was studied. Pulse tunable laser working on F_2^+-color centers in LiF (λ=830-1100 nm, pulse duration ≈ 8 ns) was used as the radiation source. It was found that a strong nonlinear Faraday effect is observed in the band associated with the resonance at the absorption edge. At first the magnitude of the specific Faraday rotation at the maximum of the spectral dependence F(hv) increases strongly with increasing P, achieving approximately double value of the linear Faraday effect. In the process the absorption coefficient decreases in the initial range of $\alpha(h\nu)$ and then increases at higher photon energies. At further increasing P nonlinear Faraday effect decreases. Spectral dependences of the specific Faraday rotation and optical density (αd) at two incident radiation intensities are shown in fig. 1,2. The dynamics of variations of F and α values was investigated too. The observed changes of F and α values increase for the radiation pulse duration. Increasing Faraday rotation and sharpening dependence $\alpha(h\nu)$ are explained by narrowing of an excitonic resonance as a result of screening of the internal electric fields by photoexcited charge carriers. Decreasing Faraday rotation under the higher incident power level is caused by that the screening of the electron-hole interaction becomes essential.

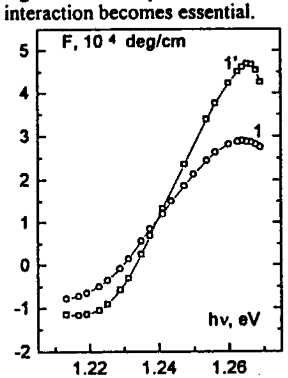

Fig.1. Dependences of F(hv), measured at T=110 K. P, kW/cm^2: 1 - 15; 1' - 470.

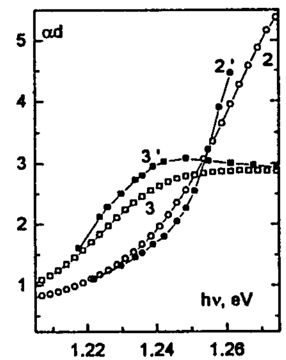

Fig.2. Dependences of αd(hv) for right- (2,2') and left- (3,3') circular polarized light. T=110 K; 2,3 -monochromator, 2',3'- laser, P=470 kW/cm^2.

NONLINEAR MAGNETO-OPTICAL KERR ROTATION

WM29

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Present contribution is devoted to the theoretical investigation of the nonlinear magneto-optical Kerr effect (NMKE). The essence of NMKE is as follows. Light beam at the frequency ω reflected from magnetic crystal is characterized by nonlinear dependence of polarization plane rotation on intensity of incident radiation. This phenomenon is similar to nonlinear magneto-optical Faraday effect which was theoretically considered and experimentally observed in semimagnetic semiconductor $Cd_{0.25}Mn_{0.75}Te$ for light transmitted through magnetic medium (see, for example, Refs. [1, 2]).

For a phenomenological description of NMKE we have considered a cubic magnetic material with the inversion center. Third-order nonlinear optical polarization $\mathbf{P}^{NL(3)}$ on the frequency ω was take into account:

$$P_i^{NL(3)} = (\chi_{ijkl}^{(3,o)} + \chi_{ijkl}^{(3,mo)})E_j E_k E_l^* . \qquad (1)$$

In Eq.(1) $\chi_{ijkl}^{(3,o)}$ and $\chi_{ijkl}^{(3,mo)}$ are cubic nonlinear optical and nonlinear magnetooptical susceptibility tensors correspondingly, and $\mathbf{E}$ is the electric field of the incident light with the frequency ω.

Different polarizations (p and s) of incident light were considered. Electric fields and intensities of reflected light were found.

Main magneto-optical configurations for reflection were investigated:
i) polar, when magnetization vector is perpendicular to crystal surface;
ii) longitudinal, when magnetization vector is parallel to the crystal surface and lies in the reflection plane;
iii) transversal, when magnetization vector is parallel to the crystal surface and perpendicular to the reflection plane.

It was shown that nonlinear rotation of polarization plane of reflected light induced by nonlinear optical as well as nonlinear magnetooptical tensors for magnetically-ordered state of crystal. For temperatures $T > T_C$ (T_C is the Curie temperature) phenomenon of nonlinear rotation is well known effect of nonlinear optical activity "in reflection" which describes only by nonmagnetic part of nonlinear optical polarization in Eq.(1).

Numerical estimations of NMKE value were made.

REFERENCES

1. J. Frey, R. Frey, C. Flytzanis, and R. Triboulet, J. Opt. Soc. Am. B. Vol. 9, 32 (1992).
2. S.B. Borisov, I.L. Lyubchanskii, A.D. Petrenko, and G.I. Trush, J. Exp. Theor. Phys. (Russia). Vol.78, 279 (1994).

18:30-20:00 **BEIGE HALL**

WN - High-Precision Measurements in Optics

WN1

Heisenberg Microscope as a Device for Quantum Variation Measurement

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Standard quantum limit appears as a result of back action. It can be illustrated by simplified example: the constant signal force acts on free probe mass during time T and one quickly measures the coordinate of mass twice: in moments $t = 0$ (the result is x_1) and in moment $t = T$ (the result is x_2). "Quickness" means that the time τ of each measurement is small enough — $\tau \ll T$. To register signal force one should measure the difference $x_- = x_1 - x_2 = x_1 - p_1 T/m - x_2$, where p_1 is back action momentum transfered to probe mass during the first measurement. The second measurement of coordinate x_2 can be made with very small error. However conversely the errors of x_1 and p_1 are dependent in accordance to uncertainty principle: $\Delta x_1 \Delta p_1 \geq \hbar/2$. Therefore the error of measurement of x_- is restricted by the standard quantum limit: $\Delta x_- \simeq \hbar T/m$.

The idea of quantum variation measurement is to use meter, allowing to measure not the coordinate but *linear combination of coordinate and back action momentum*. Let in example, discussed above, during the first measurement one measures the value $q_1 = x_1 + ap_1$) (a is a constant) and during the second measurement the coordinate $q_2 = x_2$ (as before with small error). In that case the difference q_- is the following: $q_- = q_1 - q_2 = x_1 + ap_1 - p_1 T/m - x_2$. It is easy to see that the constant a can be chosen in a proper way ($a = T/m$) to exclude information about p_1. In this case there is no restriction and standard quantum limit can be overcome. But where can we take such device?

We consider the Heisenberg microscope as an example of coordinate meter and show that it can measure the not only coordinate but *linear combination of coordinate and back action momentum.*

Let traveling along z-axis the coherent plane e.m. wave diffracts on a slit in probe mass m of mechanical oscillator without losses having frequency ω_m, which can move only along x-axis in plane $z = 0$. The signal force F_s action on oscillator should be registered. In traditional scheme the plane of detectors registering photons is placed close to slit (so that crossections of transmitted light beam and slit are approximately equal). In that case the fluctuations, describing the error of measurement of coordinate by operator $\hat{x}$, are not correlated with back action fluctuation momentum $\hat{p}$, being supplied probe mass due to diffraction in according to uncertainty principle. Their commutator is $[\hat{x}, \hat{p}] = i\hbar$. The fluctuations $\hat{x}$ and $\hat{p}$ are caused by vacuum fluctuations of e.m. field, so Heisenberg principle is valid: $\sqrt{\Delta\hat{x}^2}\sqrt{\Delta\hat{p}^2} = \hbar/2$. With increasing the power W of transmitted beam the error $\sqrt{\Delta\hat{x}^2} \sim 1/\sqrt{W}$ decreases however the back action $\sqrt{\Delta\hat{p}^2} \sim \sqrt{W}$ increases and so there is optimal value of power W_{opt} at which the minimal error of measurement — standard quantum limit — is achieved.

In order to realize the quantum variation measurement, we propose to vary the distance z between diffractional slit and plane of detectors during the time of measurement in order to overcome standard quantum limit. We would like to pay attention that in case $z \neq 0$ one measures not coordinate of mass, as in standard scheme, but the linear combination of coordinate and back action momentum

$$\hat{q} = \hat{x} + (cz/WT)\hat{p}$$

It can be understand from quasi-classical speculation: the coordinate ($\hat{q}$) of point, where photon is absorbed, is the sum: coordinate ($\hat{x}$) of point 'where photon have passed slit' plus deflection $(cz/\hbar\omega_0)\hat{p}$ due to difraction. Generalizing these speculations for many photons we can obtain formula above. Therefore we have the possibility to subtract the back action in observed value.

We have also made detail analysis, confirming that this qualitative consideration is valid.

It is worth underlining that this procedure are not the quantum nondemolition (QND) measurement. The measured value brings out small information about coordinate, momentum or any their combination. This values are strongly disturbed by measuring device if $W \gg W_{SQL}$ — in according with uncertainty principle. However this procedure allow "not to see" back action fluctuations and only *variation of coordinate* caused by signal force is registered. Such procedures may be called *quantum variation measurements.*

WN2

The Estimation of Signal Force Parameters in Quantum Variation Measurement

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Under continuous coordinate measurement back action noise of the meter is responsible for the limit of sensitivity known as standard quantum limit (SQL). In the simple optical displacement meter (Fig. 1) back action is produced by the fluctuations of light pressure force $\sim \sqrt{W}$ (W is the power of incident light wave in coherent state) and the error of coordinate measurement $\sim 1/\sqrt{W}$ defines by phase fluctuations of incident wave. Therefore there is an optimal value W_{SQL} at which the SQL sensitivity is achieved. One can also understand it in other way: reflected wave is squeezed, because movable mirror transforms the amplitude fluctuations into phase ones (Fig. 2). Movable mirror can be considered as ponderomotive kind of $\chi^{(3)}$ nonlinear susceptibility. Coherent incident wave with fluctuations depicted as circle on phase diagram are transformed into a squeezed state depicted as ellipse. For traditional scheme of registration of phase of reflected wave, the big axis of ellipse should be about the diameter of the circle, so that uncertainties of phase in reflected and in incident waves are approximately the same — these speculations give the optimal number W_{SQL} of used photons. In case of $W \gg W_{SQL}$ the ellipse is considerably squeezed. In particular, this means that uncertainty of phase in reflected wave is much larger than that for coherent incident wave. This can be also explained as consequence of large fluctuations of back action force deteriorating the sensitivity due to enhancement in phase fluctuations.

It is obvious from Fig.2, that one should measure not the phase but the squeezed quadrature component $B_{squeezed}$ of reflected wave in balance homodyne scheme (it correspond to procedure of quantum variation measurement). In this case the sensitivity will enhance with the increase of power W. However, due to delayed reaction of probe mass this squeezing is spectral dependent. To overcome this obstacle it was proposed to modulate of the phase of local oscillator wave in a proper way. In this case the minimal registered force F_{meas} is less than error F_{SQL} of SQL, if $W > W_{SQL}$

$$F_{meas} \simeq F_{SQL}\sqrt{\frac{W_{SQL}}{W}} \tag{1}$$

We show that using procedure of quantum variation measurement one can estimate parameters of the signal force (amplitude, time t_0 of arrival, frequency ω_F) with accuracy better than SQL. To do it one should divide the hole time of observation into intervals T less than time of signal force action. On first interval one should optimize procedure, for example, for measurement of amplitude, on second — for measurement of time of arrival, on third — for measurement of frequency and so on. We show that even in that case of obviously nonoptimized procedure one can overcome the SQL considerably.

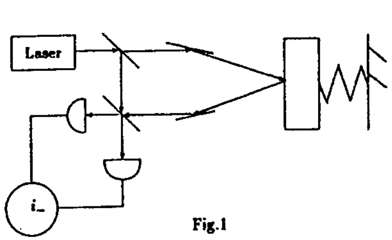

Fig.1

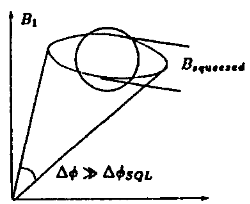

Fig.2

WN3

UNAMBIGUOUS LINEWIDTH MEASURING.

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For the purposes of microelectronics technology precise linewidth measuring is of great importance. Commonly used methods usually ignore some peculiarities of image formation in scanning optical microscope so admits some uncertainty for structure width determination. In what follows the results of detailed look at problem of linewidth measuring are presented. In most cases the measuring is concerned with exact determination of grooves and slabs sizes which have a relief and is varied in reflection ability. The relief cause an interference phenomena at the edges of the object under study. Thus amplitude oscillations in obtained image occur and make it difficult to recognise true positions of the structure edges. Comprehensive analysis within the framework of scalar Fraunhofer diffraction gives the following form for field amplitude of light reflected by the object under study in observation plane

$$A(x_4) = R_1 \int_{-\infty}^{\infty} G(x_2) * \exp(2ix_2x_4)dx_2 + \delta z e^{i\varphi} \int_{X_s-d}^{X_s-d} G(x_2) * \exp(2ix_2x_4)dx_2$$

here R_1 reflection coefficient for substrate, G(x) shape function of illuminating beam,

$$\delta z = \left[R_1^2 + R_2^2 - 2R_1 R_2 \cos(\alpha)\right]^{\frac{1}{2}}, \alpha = {}^{4\pi h}\!/_{\lambda}, X_S \text{ scan coordinate}, \varphi = \frac{R_1 \sin(\alpha)}{R_2 - R_1 \cos(\alpha)}$$

It could be seen from equation that field amplitude depends both on relief and reflection coefficient. Thus one needs to measure both phase and amplitude of reflected light for true profile sizes to be determined. In experiment phase and amplitude variations have been measured with differential phase-amplitude microscope.[1] The experimental data were treated then with mathematical procedure to find real width and depth of 3-D structure. Results were in a good agreement with independent studies.

References:

1.S.I. Bozhevolnyi, A.V. Postnikov, P.S. Radko, SPIE 1556 (1991) 178.

WN4

THE USE OF SELF-FOCUSING EFFECT FOR MEASUREMENTS OF SMALL WAVEFRONT DISTORTIONS

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In the present work we propose a method of measurements of wave front distortions based on determination of a decline angle of a thin laser beam at each aperture point of a tested detail. The diffraction of the beams in a linear medium makes it impossible to measure the angle of a decline much less than its diffraction limit. This approximately corresponds to the accuracy of an interferometer. The propagation of a beam in a medium with cubic nonlinearity causes self-focusing which partially suppresses the diffraction. This has allowed us to essentially raise the measurement accuracy.

We realized this idea experimentally. 2.5 mm Gaussian beam was split into two identical beams: reference and measurement. Then the diameters of the beams were decreased in eight times by two identical telescope objectives, the focal plane of which was combined with a plane of target windows of a nonlinear cell. On achieving the self-focusing threshold (1-2 MW) a «point of self-focusing» with the radius of 15 micron is observed in cross section of the beams. If an optical element with a small wedge is placed into the measurement beam, the relative position of the «points» will be changed. As radius of these «points» is much less than the radius of beams for a linear medium, we easily measured the relative angular shift of beams with accuracy of one microradian. In our case the accuracy corresponded to $\lambda/350$. We also measured distribution of phase front decline for three long-focus lenses with focuses 67 m, 208 m, 1218 m correspondingly, with aperture as little as 1 cm and step of measurement 1 mm. In the latter lens the local declines of the phase front surface from the calculated spherical value were found with accuracy better than $\lambda/350$.

WN5

Effects of polarization nonreciprocity in fiber ring interferometers

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The criteria, distinguishing reciprocal medium from nonreciprocal one are well known [1]. However, with the development of fiber ring interferometry, effects of phase nonreciprocity caused by polarization effects, have been found in media which are reciprocal in the traditional meaning. The polarization effects are when waves which have been equally polarized at the input, become differently polarized after passing through a fiber ring interferometer (FRI) in counter directions. There are some papers which provide calculations and results of experiments on the effects of polarization nonreciprocity for concrete schemes [2-3]. The aim of the present work is to summarize the known results and to analyze the effects of polarization nonreciprocity basing on the general Jones matrix of FRI which satisfies the well-known criterion of reciprocity [1]. The analysis has shown, in particular, that an interference signal in reciprocal and stationary case does not contain information on the value and sign of nonreciprocal phase, since when the phase is changed, a compensating change in amplitude of the interference signal occurs. Conditions necessary for observation and manifestation of the effects of polarization nonreciprocity have been considered. We have also discussed the difference between the polarization nonreciprocity and traditional nonreciprocity effects. It is shown that the nonreciprocal effects can appear in FRI with contour made of single-polarization fiber. The difference in conditions of polarization reciprocity in a fiber contour and a straight fiber line has been considered.

References

1. V.L.Ginsburg, Propagation of electromagnetic waves in plasma, 1960 2. G.Schiffner et al., Applied optics, 1979, v. 18, No. 13, p. 2096-2097 3. G.B.Malykin, Optics and spectroscopy, 1997, v. 83, No. 6, p. 1013-1015

WN6

Polarization control in two-pass anysotropic optical systems

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Polarization control and elimination of polarisation fadinds in fiber-optical schemes, and related problems are discussed. As shown in [1] the problem of polarization fadings can be exhaustively solved in two-pass optical schemes by means of 45-degree Faraday retroreflector (45-FR). Today 45-FR method is in wide practical use.

In this report this method is extended to more complicated optical systems. General polarization properties of two-pass anysotropic systems are considered. Within the frames of Jones matrix method, equivalency theorems for such systems are obtained. Particular attention is paid to Mach-Zender type schemes. It is found that in two-pass Mach-Zender interferometer 45-FR ensures complete restoration of initial polarization but does not eliminate fadings. Some other interferometric schemes are analyzed including recently proposed two-pass schemes with ring resonators.

New variants of 45-FRs are discussed. It is shown that 45-FR can be made on the base of Sagnac polarization interferometer [2]. Parameters of this 45-FR do not depend on Faraday cell parameters. The variant appliable to practical use is proposed.

Alternative (to 45-FR) methods of polarization control and elimination of parasitic effects of optical anysotroipy in two-pass schemes are discussed. Simple and effective schemes with phase plates are considered. It is shown that such schemes may be applied to study small effects of optical anysotropy in crystals placed to external magnetic and electric fields.

[1] V.M.Gelikonov, D.D.Gusovsky, V.I.Leonov, and M.A.Novikov, *JTPh. Lett.* 13, 775-779 (1987)
[2] M.A.Novikov, *Radioengineering and Electronics (USSR)*, 21, 904-905 (1976)

WN7

DECREASE OF QUANTUM NOISE IN MICROPHASEMETRY USING MODULATION METHOD

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The recent interest in the development of high-sensitive low frequency microphasemetry methods has been inspired, in particular, by the programs for gravitational waves measurement. The present work provides a comparative analysis of the influence of quantum noise on the limit sensitivity of microphasemetry in two regimes: the common regime of operation in the steep region and the regime at the minimum of an interferogram with modulation of phase difference. It is shown that themodulation method can reduce the quantum noise in 2.5 times as compared with the conventional method [1] and allows to eliminate low frequency flicker noise. We have analysed the case when Fabry-Perot cavities are used as arms of a Michelson interferometer. The analysis has demonstrated the possibility of further increase in the limit sensitivity depending on the cavity quality. Along with quantum fluctuations, we have also considered the influence of excessive fluctuations of intensity and frequency in laser. Optimal amplitudes of modulation have been calculated to achieve maximum increase insensitivity.

1. Andronova I.A., Bershtain I.L., and Zaitcev U.I., Izv. Akademii nauk of the USSR vol. 46, N.8, 1590-1593 (1982)

WN8

A TUNABLE DIODE LASER WITH ORTHOGONALLY POLARIZED MODES

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Interaction of atoms with polychromatic optical fields keeps to draw great attention [1]. Such fields are produced by independent lasers or a laser and a modulator, or by a two-mode laser. The last case provides both a large degree of correlation of technical noises and independence of phases, and is of particular

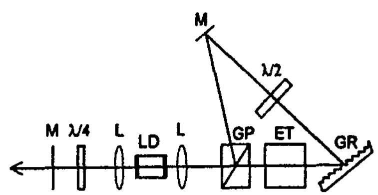

Fig.1

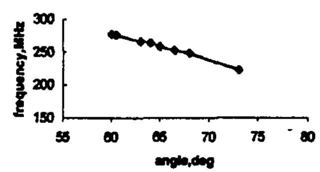

Fig.2

interest [2]. Two-mode gas lasers are well known, but two-mode diode lasers with 0.1-10 GHz mode separation have not been reported. The only exclusion is [3] in which two orthogonally polarized modes were excited (decreased mode competition). The frequency difference between them was controlled by the rotation of one of the intracavity λ/4 plates. We replaced one λ/4 plate by a loop with a grating and a λ/2 plate (Fig.1). It provides the symmetry of the grating efficiencies for two polarizations and possibility of coarse tuning. The two mode separation is finely tuned by rotation of the λ/4 plate (Fig.2). The noise properties of the laser will be described in details.

1. A.S.Zibrov, M.Lukin, L.Hollberg et al. Phys.Rev.Lett., v.76, 21, pp.3935-3938,1996
2. A.M.Lukin, M. Fleishhauer et al. "Intracavity electromagnetically induced transparency". Submitted to Opt.Lett.
3. S.Wakana, M.Shirasaki et al. Appl. Phys.Lett. 50 (22), pp.1547-1549, 1987

WN9

Software algorithms for laser beam diagnostics

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The computation algorithms that were developed can be used for any application or any experiment, which requires tri-dimensional visualization of the experimental data. The information acquired by a CCD camera is stored as a matrix of gray levels (the algorithm works for any size of the input matrix), the matrix is processed and the result is a 3D representation of the beam intensity profile.

An interpolation-and-averaging method was developed, in order to make the visualization faster. The averaging has also the advantages of decreasing the illumination and sampling errors, while the displayed surface is similar with the initial one.

The TEM mode structure of the investigated laser beam is also determined from the matrix of power densities. The experimental data are regarded as a linear combination of Gauss-Hermite functions and the coefficients of the linear expansion are determined by solving a matrix equation. These coefficients yield to the weights of different TEM modes in the structure of the investigated beam.

The experimental works were performed using a silicon CCD camera, an LBA-100 laser beam analyzer and PC compatible computer. There were studied He-Ne, He-Se, pulsed and continuos wave Nd-YAG lasers, as well as laser diodes of various wavelength.

WN10

LASER INTERFEROMETER WITH THE MULTIBEAM CAVITY

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The principle of action and the design of a laser interferometer is presented. The device is constructed on the base of multibeam cavity and is intended for the registration of small spatial changes of refractivity. As its prototype there was used a multibeam interferometer [1] which consists of an active elements settled inside the unified plane-parallel laser cavity. One can define the spatial variations of sample refractivity by putting the sample in the cavity and recording the beats of the frequencies between the different channels of generation. In contrast to its prototype the suggested scheme of the laser interferometer has only one active element which is put inside the confocal multibeam cavity [2]. An inner-cavity mask having a system of holes allows the simultaneous excitation of the axial TEM_{00}-mode and a system of V-shape modes characteristic for a confocal cavity. The axial mode beam serves as a reference beam, the V-modes beam - as the signal ones. The using of the unified active element and of the specific geometry of V-shape modes causes the higher jamproofing of this device in comparison with its prototype. By using of the typical gas-discharged tube of He-Ne laser it allows to register the refractivity changes of about 10^{-10}.without undertaking special vibration-proof measures. An important peculiarity of this interferometer consists in the fact that the V-modes locking under the small frequency detuning does not reduce the sensitivity of the device. The additional investigations show that the V-modes locking take place only in the even orders of the "comb" of the interferometer frequencies and only at the frequency of the axial mode possessing the highest gain. That is why it is possible to conduct the necessary measurements by measuring of the beats between the axial mode and the odd V-modes modifications even under the conditions of frequency locking with high accuracy.

References:

1. Batrakov A.S., Butusov M.M., et. al. Lazernye izmeritelnye sistemy (Measuring systems with lasers).- Moscow.: Radio i Sviaz. 1981. (in russian).

2. Vasiliev A.B. Korolenko P.V., Tikhomirov V.N. //Sov. J. Quantum Electron. 20 1378 (1990)

WN11

A NEW APPROACH TO OPTICAL MEASUREMENTS OF SMALL OBJECTS WITH SUPERRESOLUTION.

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This paper deals with the application of optical superresolution technique to measuring small particles said to be secondary light sources with various scales of sizes - from micrometers to nanometers. The mathematical modelling is based on the superposition of solutions of Maxwell's equations but unlike the well-known MMP-method [1] it encloses linearly polarised plane waves in complex and vector form as functions of spatial frequencies (ν_x, ν_y) corresponding both to the propagating and evanescent light. By this the near-field and far-field descriptions are combined in one model. Principal advantage of this model is the use of a set of Fourier transformations as a nucleus of the procedure. The use of Fourier transform technique may meet troubles for objects with subwavelength dimensions and to process such objects the inverted distributions must be represented by the row of eigenfunctions of the Fourier transform [2]. The main direct matrix expression for light distribution is $\mathbf{B}_{ij} = \mathrm{P}_{ij}^{-1}(\nu_x, \nu_y) \cdot \mathrm{F}^{-1}[\mathrm{S}]$, where $\mathbf{S}$ is the diagonal matrix of dimensions of a particle, $\mathrm{P}_{ij}^{-1}(\nu_x, \nu_y)$ – a matrix operator similar to a matrix of rotations according to the assumed definition of vector amplitudes of plane waves, F^{-1} – the inverse Fourier transform operator. The inverse matrix formula for the restored dimensions is $\mathbf{S}' = \mathrm{F}\left[\mathbf{P}_{ij} \cdot \mathbf{B}'\right]$. The values in $\mathbf{S}$ and $\mathbf{S}'$ do not coincide but they may be quite close provided that the redefinition of $\mathbf{B}'$ by the use of Fourier transform eigenfunctions is made.

1. L.Novotny, D.W.Pohl, P.Regli, J. Opt. Soc. Am. A.,1994,V.11, N. 6, P. 1768-1779.
2. Stratton J.A., Morse P.M., Chu L.J., Little J.D.C., Corbato F.J. Spheroidal wave functions, John Wiley and Sons, Inc., N. Y. 1956.

WN12 White light interferometer for high precision thickness/refractive index measurements

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The new white light interferometer for high precision measurements of thickness or refractive index of transparent layers is investigated experimentally. The interferometer comprises low-coherent light source *S*, reference interferometer formed by semitransparent mirrors *R1*, *R2* which is linked with sample layer *SL* by fiber-optical cable *FOC* (see Fig.). The interference in the interferometer can be seen only if

$$|2l - 2nd| < l_c$$

where $2l$ is delay in reference interferometer, d is the thickness of sample layer, n is its refractive index, l_c is coherence length. The main feature of the inteferometer is that the paths of all of interfering waves ouside the reference interferometer and sample layer are the same. Any instabilities of optical length of the common path (such as "mirage" effects in the air over the sample layer) as well as polarization effects in the fiber optical cable do not impact the interference. By using of optical fiber the measuring unit can be isolated from any influences of environment around the sample layer such as heat or cold, vibrations, electromagnetic fields, etc. In the experiment, the permanent measurement of the thickness of glass ribbon heated up to 500 C is demonstrated. The different variants of the interferometer are discussed including the scheme for nontransparent objects thickness measurements.

WN13 ACCELERATION DETECTION USING SURFACE PLASMON MICROSCOPY

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Opportunities of the immersion surface plasmon (SP) microscopy [1,2] for acceleration detection follow from dependence of SP excitation efficiency not on the optical properties of the sample only, but on the properties and thickness h of the coupling layer as well.

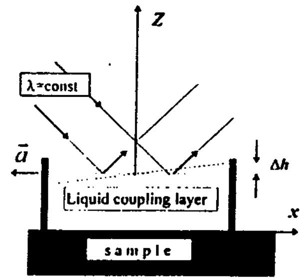

Fig. **Sensitive element of the immersion SP accelerometer.**

A scheme of an immersion SP-accelerometer and it's functioning are described in the report. The crucial part of the device is it's sensitive element (see Fig.). The device's motion with a uniform acceleration $\vec{a}$ along the axis x results in a linear deformation of the coupling layer. The increment of the layer's thickness Δh causes a variation of SP excitation efficiency resulting in a corresponding change of the reflected light intensity. Using a previously calculated dependence of the reflectivity on h, one can estimate the value of Δh at any point x and find the magnitude of $|\vec{a}|$.

Computations proved that using the device with the measuring base of 20 mm one can determine $|\vec{a}|$ with the accuracy of 10^{-6} m/s^2. The accuracy may be increased further by employing the phase SP-microscopy [3].

Refrences.

1. A.A.Tishchenko, A.K.Nikitin, *"Surface Electromagnetic Waves (SEW) in optical microscopy"*, Bull. PFUR (ser. phys.), No.1, pp. 114-121, 1993.
2. A.P.Gorobets, A.P.Loginov, A.K.Nikitin, A.A.Tishchenko, *"S E W- microscopy of opaque samples"*, Proc. SPIE, Vol.2799, pp. 449 - 457, 1996.
3. A.K.Nikitin, A.A.Tishchenko, *"Phase SEW-microscopy"*, Technical Physics Letters, Vol.17, No.11, pp. 76-79, 1991.

WN14

Frequency shift of radiation under amplification in single-pass pulsed YAG:Nd amplifier. Saturated amplification regime.

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Investigation of frequency shifts of radiation during the process of its amplification in pulsed amplifiers is of great importance, because the radiation linewidth is the one of the main factors which determine the accuracy of velocity measurements, if such a system acts as a probe radiation source [1-3].

In this paper we present the theory of amplification of monochrome laser radiation during its propagation through the single-pass YAG:Nd amplifier in the saturated amplification regime. Calculations of amplitude and frequency shift of the amplified radiation were based on this theory. Analysis of experimental data shows that the main contribution to the frequency shift in the case of single-pass lamp-pumped amplifier is given by the thermooptical component which corresponds to the temperature dependence of refraction index and thermal expansion of the active medium. The thermooptical component is about 4 kHz under the following parameters of amplifier: pump pulse energy – 60 J, pulse duration – 150 μs.

Frequency shift determined by resonant component, which corresponds to nonstationarity of population inversion and amplification line of the active medium, reaches its maximum at the detuning from the center of amplification line of 16..20 GHz. Decrease of frequency shift of narrow-line radiation under its amplification in the lamp-pumped single-pass pulsed YAG amplifier is possible due to mutual compensation of resonant and thermooptical components, but the efficiency of this compensation for the lamp-pumped amplifier is limited by the significant decrease of the gain.

1. A.A.Mak, etc., *Proc. SPIE*, 1991, v.1410, pp.233-243
2. V.M.Gordienko etc., *Quantum Electronics*, 1994, v.21, N3, pp.284-290
3. I.V.Golovnin etc., *Quantum Electronics*, 1996, v.23, N7, pp.606-610

WN15

Experimental set-up for measurements of dynamic shifts of radiation frequency in the near IR range.

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Necessity of measurement of small frequency shifts (of order of 1 kHz) with the carrier frequency of visible and near IR range arises during investigations of frequency sweeping mechanisms of monochrome radiation under its amplification in the pulsed YAG:Nd amplifier [1,2]

Laser radiation was entered to the Mach-Zender interferometer, with one of the arms containing the active YAG element under investigation. Acousto-optical modulator made of melted quartz was used to split the beam and, at the same time, to shift radiation frequency in the interferometer support arm by 50 MHz. The beat signal, containing information of the frequency shift on the carrier frequency of 50 MHz was registered by photodetector. The signal from photodetector was amplified by resonant amplifier with the center frequency of 50 MHz. The RF heterodyne system was then used to decrease the carriage frequency downto 1 MHz. This signal, containing information concerning to the frequency shift, was registered by memory oscilloscope and was then developed by special algorithm on the personal computer.

Experimental set-up and data processing method, presented in this work, allow to carry out measurements of dynamics of monochrome visible or near IR radiation frequency shifts with accuracy of 150 Hz during the period of 100 μs.

1. A.A.Mak, etc., *Proc. SPIE*, 1991, v.1410, pp.233-243
2. I.V.Golovnin etc., *Quantum Electronics*, 1996, v.23, N7, pp.606-610

WN16

PRECISION SIZING OF MOVING LARGE PARTICLES USING DIFFRACTIONAL SPLITTING OF DOPPLER LINES

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It is observed usually, that translational motion of a particle generates a single line in registered Doppler spectrum. Recent experimental [1] and theoretical [1,2] studies showed the possibility of the doublet-type splitting of Doppler line from a large particle moving translationally through intersecting Gaussian beams. The splitting occurs for specific angular conditions of the probing and the registration. The report gives the formulation and analysis of three possible mechanisms of Doppler line splitting. Two diffractional mechanisms are the bounded beam *diffraction mechanism* and the *transient geometry* mechanism, while the third one has the photometrical nature. The angular conditions for observation of the diffractional splitting of Doppler line are:

$$\frac{2a}{\Lambda} = |n-(m+0.5)|\,, \qquad \alpha_{nm} = \frac{n+(m+0.5)}{|n-(m+0.5)|}\theta_0$$

Here a is the particle radius, Λ is the interference fringe spacing, $2\theta_0$ is the beams intersection angle, α_{nm} is the angular position of the detector, coinciding simultaneously with the n-th diffraction minimum for one of the probing beams and m-th diffraction maximum for another probing beam. For the photometrical mechanism of Doppler line splitting the observation conditions are different: $(2a/\Lambda)=n$, where n=1,2,... The splitting phenomenon enables the precise distant particle sizing.

1. V.A. Grechikhin, B.S. Rinkevichius, A.V. Stepanov, A.V. Tolkachev, V.L. Kononenko. *IMechE Conference Transactions, 1996-3, pp.* 393-402.
2. V.L. Kononenko. Proceedings of the 7th International Conference "Laser Anemometry: Advances and Applications", B. Ruck, A. Leder, D. Dopheide, Editors. September 8-11, 1997, Karlsruhe, Germany, pp. 317-324.

WN17

THE CALCULATION OF SAGNAC EFFECT IN NONPLANE WAVEGUIDS

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In the paper the propagation of electromagnetic waves in nonplane waveguids is consider. The analitic calculation of Sagnac effect for such waveguids is proposed. In the last time the interest to the high-sensitive fiber-optic rotation transduser increased. A work of this devices based on the Sagnac effect, and they use a singlemode waveguids as "light polygon". Then the problem of propagation of electromagnetic waves and the calculation of Sagnac effect in singlemode waveguids has a great significance. Let us place the waveguids in plane space. The axis line of waveguids is a something nonplane curve. We propose this line has a nonzero curvature k and twist T. We propose that the lines of light motion are isotropic geodesic lines of a certain fourdimentional Rimannian space. The metric of this space was found in [1]. Let us place this waveguid on a laboratory turntable. In revolving coordinate system we separate the threedimension part and define a natural time. The value of Sagnac effect determine by integration of this natural time. We considered also some particular cases (the waveguid is a circle and a helical line). So we propose that this effect depend upon configuration of waveguid.

[1]. Staroverova M.E., Bashkov B.И. Proc. Int. Conf. "Geometrization of Physics II", Kazan, October 1995, p. 175.

Picosecond polarimetry and deflectometry with quantum-noise-limited sensitivity

WN18

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The sensitivity of time-resolved precise laser measurements, for instance in nonlinear spectroscopy or in electrooptical sampling, may approach the quantum-noise limit determined by Poissonian fluctuations of laser light. This limit can be easily achieved with highly stable cw lasers using lock-in photodetection. However, it is more difficult to reach the shot-noise-limited sensitivity in precise measurements with mode-locked cw-pumped lasers because of their high noise level. However the laser noise energy decreases with frequency and at frequencies higher than 1 MHz one can realize lock-in detection with quantum-noise-limited sensitivity. In this work we present the highly sensitive radio-frequency lock-in photodetection technique, which is applied to *two types of transient pump-probe picosecond measurements:* polarimetry and deflectometry.

We have developed a simple and very effective radio frequency lock-in photodetection system implemented as an attachment to a standard low-frequency lock-in amplifier. The attachment includes a photodetector and a frequency down-converter and works at a single fixed radio frequency of 6.2 MHz. The resonant single-frequency design provides high gain and high selectivity, which have enabled us to easily attain the shot-noise-limited sensitivity. *We use this photodetection system* with a cw-pumped picosecond Nd:YAG laser. We have found that the peak-to-peak sensitivity to relative optical power change $\delta P/P$ at 6.2 MHz is determined only by the value of the photocurrent and makes a value of $\delta P/P \simeq 5 \times 10^{-7}$ $Hz^{-1/2}$ for the typical photocurrent of 0.2 mA [1]. The pointing noise of the laser has been evaluated using a position-sensitive photodetector. We have found that the sensitivity of the position-sensitive measurements is also determined only by Poissonian fluctuations of the laser power.

In the polarization experiments a linearly polarized pump beam induces optical anisotropy in a polyacetylene film. The photoinduced change in the polarization *state of a probe beam is measured.* The peak-to-peak sensitivity of ~ 0.1 μrad $Hz^{-1/2}$ to small polarization rotation has been achieved [2].

In the photoacoustic experiments the pump beam is absorbed near the sample surface (Ge, Al). This induces its local deformation. The deformed surface deflects the reflected probe beam. The deflection angle is measured with a position-sensitive detector. We have attained the peak-to-peak sensitivity to deflection angle $\simeq$0.1 nrad $Hz^{-1/2}$ corresponding to surface displacement $\simeq$0.1 pm $Hz^{-1/2}$ [2].

1. D.Yu. Paraschuk, T.A. Kulakov, O.Yu. Nedopekin, N.V. Chigarev, and X.Y. Pan, Rev. Sci. Instrum. **68**, 3989 (1997).
2. N.V. Chigarev, O.Yu. Nedopekin, X.Y. Pan, and D.Yu. Paraschuk, "Pribori i tekhnika experimenta" (in press).

QUANTUM NOISES AND SENSITIVITY OF AN OPTICAL PARAMETRIC SYSTEM WITH TWO-COMPONENT PUMP

WN19

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The problem of the improvement of a sensitivity of parametric optomechanical transducers has large practical and scientific significance. For example, the sensitivity of a gravitational bar detector with an optical readout system is defined by a following expression $F_{\min} = kF_Q$, is the standart quantum limit. Coefficient k in this expression is about unity for traditional measurement shemes. The physical source of this result is the parametric transformation of the intrinsic gaussian noises in degenerate regime . The reduce of the excess noises is possible for special parametric devices with two-component pump $A(t) = A_0 \cos\omega_p t \cos\omega_m t = (A_0/2)(\cos\omega_1 t + \cos\omega_2 t)$, where ω_p –is the frequency of the pump, $\omega_{1,2} = \omega_p \pm \omega_m$ – are the combinational frequencies, ω_m is the resonant frequence of a mechanical system. For this type of the parametric system one can get the following estimation for $k = k^* \approx (2\delta_e/\omega_m)^{1/2}$, where $\delta_e << \omega_m$ – is the bandwidth of an interferometer Fabry-Perot. On another hand one can show that $k \to 0$ for three-frequency parametric systems when an optimal processing algorithm of the output signal is used. Therefore the this result $k = k^*$ is the consequence of the non-optimal processing algorithm which does not take into account a "thin structure" of the output noises. The optimal algorithm is based on the general ideas of the detection theory for multidimension vector signals. In this algorithm for sufficient statics Z one has $Z = \sum_{i=1}^{2} \int_0^T y_i(t)\rho_i(t)dt$, $i = 1,2$, where $y_i(t)$ are the quadvature components of the output signal, $\rho_i(t)$ – are the reference functions which one can find using the mutual correlaton between intrinsic gaussian noises at the combinational frequencies $\omega_c = \omega_p \pm 2\omega_m$ and ω_p.

The calculation of the minimal detected amplitude of a useful signal for the parametric systems with two-component pump gives the following estimation for parameter k: $k \approx \sqrt{(2\delta_e/\omega_m)(1 - \mathrm{Im}^2 r)}$, where r is a mutual correlation coefficient between the Langeven noises of the transducer considered as a linear four-port device. For an ideal optomechanical transducer $r \approx j$ and consequently there is no physical limitations on the sensitivity of parametric measuring systems with two-component pump.

WN20

FIELD SPACE-TIME MEASUREMENTS IN FUNDAMENTAL PHYSICS

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In modern practice, the laser technique of precise space-time measurements is based on the procedure of emitting and detecting optical signals and thereby the properties of these optical signals in themselves are extended to the results proper of similar measurements in one form or another. However, if from the outset we proceed from experimentally established invariant space-time parameters, it turns out that results of the measurements can be represented in terms of a massless spinor field. From the standpoint of operating the signals, it should be noted, that the equations of Maxwell's electrodynamics may be rewritten in the form of Dirac equations, wherein the mass is put equal to zero. But generally in the massless case Dirac equations fall apart into a pair of Weil equations, describing an evolution of field, whose spin equals 1/2. Since the sources of spinor fields are missing, the study of properties, peculiar to a massless spinor field in the context of interpreting the space-time measurements under consideration, is showing up as the most available. The analysis of amplitude dynamics intrinsic in a spinor field allows one to interprete the results of measurements as an effect of the interferening amplitudes. In its own turn, the features of phase characteristics leads to originating the nodal filaments followed by their topologocal quantization, because a nonintegrability of the field phase proves to be acceptable. Quantization of this kind is attributed to the fact that in the course of fulfilling the field, in particular optical, space-time measurements we have dealings evidently with a wave process in a space, which is topologically closed by itself in one of its own dimensions. The part of the cyclic coordinate is played by the field action. Thus, the representation under proposal for results of the space-time measurements in terms of a massless half-integer spin field makes it possible to reveal some new structures and to trace the associations of experimentally established invariant parameters inherent in measurements with originating both the nodal filaments and the quantum phenomena.

WN21

DETERMINATION OF PARAMETERS OF STATISTICAL ENSEMBLE OF MICROOBJECTS IN WAVEGUIDE OPTICAL MICROSCOPE

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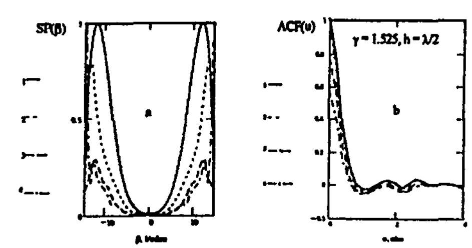
The computer modeling of a solution of the direct and inverse problems for a waveguide optical microscope (WOMP) is accomplished for the autocorrelation function ACF (of statistical surface roughness of quartz plate) like the damped cosine (i.e. the power spectral density is "band-limited" noise with Gaussian spectrum). The optimization of solutions was performed in part by variation of the effective refractive index γ of waveguide. The inverse problem was made with the use of the Tikhonov's regularization and analytical extension of power spectral density.

In Fig. normalized solutions are shown: a – intensity response function (SP(β)) of WOMP in the Fourier plane with different γ (1-1.479: 2.9SP(β), 2-1.525, 3-1.556, 4-1.571); b – ACF of the surface roughness: given ACF (1) and restored ACF with different regularization parameter μ (2-0.5, 3-2.0, 4-5.0). When μ = 0.5 the rms error of restoration of ACF is less than 5% and the error of determining of the mean correlation radius r = 0.32 mkm of the surface roughness is about 6%.

The limiting lateral resolution in WOMP by correlation radius for the high signal-to-noise ratio may be a ~ 10-15-times less than Abbe's diffraction limit.



WN22

STEP-HEIGHT AND STEP-TRANSITION MEASUREMENTS WITH HETERODYNE DIFFERENTIAL INTERFEROMETER

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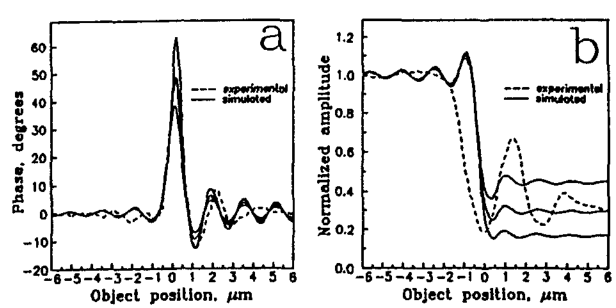
The investigated step profile was formed by the edge of photoresist mask ($h \simeq 0.5\,\mu m$) deposited on the Si-substrate. A local reflection coefficient approach has been applied for object modelling which took into account an interference effect in photoresist film and reflection amplitude jump at film's interface. For interferometer response monitoring a point detector was located at the center of Fourier-plane and thus the transfer function was reduced to the form of the focal spot. The microstep parameters have been determinated through the direct optical problem of the interferometer. By means of profile parameters variation we fitted simulated response to experimental one for both phase and amplitude components, obtained an unique solution and determined the sensitivity of the method to small (submicron) variations of the object parameters. The variation of simulated complex response for different step heights is demonstrated in figure: for phase (a) and amplitude (b). The sensitivity of the method is determined by the minimum variation of object parameter which results in response variation exceeding the noise component of experimental response. For investigated object the sensitivity was estimated at 10 nm for step height and 0.1 μm for step transition. The parameters determined from experimental response were in a good agreement with the data derived with the scanning electron microscope.



WN23

On observation of narrow resonances with increased contrast in the passband of an active interferometer.

S.N.Bagayev, A.A.Kurbatov, E.A.Titov

The behavior of narrow absorption resonances is investigated on the shape of the passband line of an active interferometer under variation of the frequency of the external field. The active interferometer has two cells - the absorbing call and the amplifying cell and is below the generation threshold. In the absence of amplification we have the case of an external absorbing cell with the resonance amplitude which is proportional to the gas pressure to the third power, if the homogeneous width of the absorption line is much larger than the transit-time width of the line. In the transit-time area, the resonance amplitude is proportional to the gas pressure to the fifth power. The amplitude of the resonance can increase by an order of magnitude versus the pressure by increasing the coefficient of amplification so as to compensate for the linear losses. In this case the width of the absorption resonance must be smaller than the passband of the active interferometer. On further increase in amplification, we observe only the passband of the active interferometer, because it becomes narrower than the width of the absorption resonance. The influence of noise of the external signal on the contrast of the absorption resonances is also investigated.

WN24

Raman scattering for the 2^1S-2^3S transition of helium

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The 2^1S-2^3S transition of helium is of interest for high resolution laser spectroscopy since the natural line width of this transition is equal 8 Hz. The 2^1S state (para-helium) has the lifetime $2.0 \cdot 10^{-2}$ s, which is governed by two-photon decay to the ground state 1^1S, and 2^3S (ortho-helium) - $7.9 \cdot 10^3$ s, corresponding to M1-transition to the ground state.

Here we consider stimulated Raman scattering, connected with the 2^1S-2^3S transition. The pumping field is a running wave which frequency is close to the frequency of the 2^3S-2^3P_1 ($\lambda = 1083$ nm) transition, and the stimulated scattering - the standing wave with the frequency close to the 2^3P_1-2^1S ($\lambda' = 3561$ nm) transition. In the Raman scattering line form there is a resonance with natural width of the forbidden 2^1S-2^3S transition [1-3] which we offer to use for the exact measurement of the 2^1S-2^3S transition frequency.

According to our estimates a linear gain coefficient of a scattering wave can be made $\alpha_0 = 10^{-4}$ 1/cm (the density of atoms at the 2^3S state is about 10^{11} 1/cm^3 and pumping wave power is 10 W/cm^2). The decision of the equations for a density matrix of gas of three-level atoms in the third order of the perturbation theory gives the following expression for a gain coefficient of the scattering wave

$$\alpha = \alpha_0 \left\{ 1 - \eta \frac{\Gamma^2}{\Gamma^2 + (\Omega' - \Omega)^2} \right\},$$

where Ω - detuning of the pumping wave, Ω' - detuning of the scattering wave. Expression describes the resonance at $\Omega'=\Omega$ with a width of the forbidden transition Γ. We choose saturation parameter $\eta=0.1$ which corresponds to 10 W/cm^2 scattering wave power.

Estimating the width of the resonance we were guided by the value 100 kHz. The degree of tuning of the laser frequency to a resonance center is 10^{-3} of its width and therefore the accuracy of the 2^1S-2^3S transition frequency measurement we estimate about 100 Hz (relative accuracy 10^{-12}).

It has a large resonance intensity that may be useful for some applications. Such gain coefficient does not exclude an opportunity of generation on the 2^1S-2^3S transition with 3561 nm wavelength.

References

1. E.V.Baklanov, I.M.Beterov, V.P.Chebotayev, and B.Y.Dubetsky. Appl.Phys. **11**, 75 (1976).
2. E.V.Baklanov, I.M.Beterov, V.P.Chebotayev, and B.Y.Dubetsky. Pis'ma Zh. Eksp. Teor. Fiz., 22, 289 (1975).
3. V.C.Letokhov, V.P.Chebotayev. *Ultrahigh-Resolution Nonlinear Laser Spectroscopy.* Moscow, Nauka, 1990.

WN25

Paper is not available

18:30-20:00 **PRESIDENT'S HALL**

WO - Nonlinear Optical Phenomena II

WO1

BRIGHT PHOTOREFRACTIVE SPATIAL SOLITONS IN OPTICAL WAVEGUIDES ON SBN

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We have realized the effects of spatial soliton formation due to the photorefra-ctive self - focusing of light beams in a planar optical waveguide formed in cerium - doped strontium - barium niobate crystals (SBN:Ce) by implantation of He^{+} ions. The crystal dimension was 2,0×6,0×3,3 mm^3 with 3,3 mm edges along the c - axis and 6,0 mm length for a light path. *The waveguide layer 4,5 µm thick supported only TE modes.* The radiation of an Ar - ion (λ = 514 nm), a He - Ne (λ = 633 nm) and semiconductor (λ = 780 nm) lasers was coupled into the waveguide through its edge by 20× microscopic lens. The initial size of light spots on the in - coupling waveguide face was varied in the range of 9 + 30 µm. To provide the soliton regime, we applied the electric field up to 10 kV/cm along the crystal c - axis.

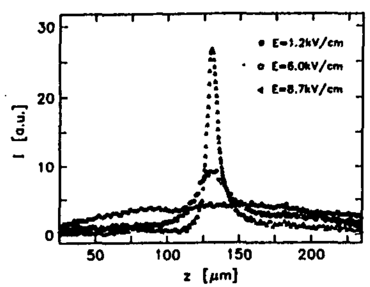

Fig. 1.

The particular results are illustrated by fig.1. Here the beam profiles at the outcopling waveguide face correspon-ding *to different electric fields are shown* for the case of the steady - state (screening) bright solitons. The input power and initial size of He-Ne laser beam were 4,3 µW and 10 µm, and the *time of soliton formation was as less than* 1 s.

The time behavior of light beam profiles was also investigated in experiments and their transient self - focusing (the quasi - steady - state solitons) was observed on the time scale of 50 - 100 ms.

WO2

PHASE EFFECTS AND SOLITONS IN THE MULTIPLE FREQUENCY OPO

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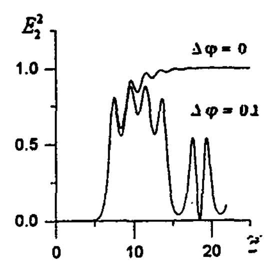
In OPO with multiple frequencies the total energy transfer of pump wave (3ω) to SH (2ω) can be achieved in QPM crystal [1]. *Minimum of conversion length corresponds* to $\beta_2 = \sqrt{12}\beta_3$, where β_i are nonlinear coefficients responsible for SHG and three-wave parametric interaction respectively.

Firstly, the influence of the input signal phase shift on energy conversion efficiency is studied. Analysis of envelope equations and results of numerical simulation show that the phase shift does not influence on parametric interaction until 2/3 of pump energy is transferred to signal wave. Then SHG channel becomes stronger and the whole process becomes very sensitive to harmonic phases. We derived simple formula for SH amplitude decrease $E_{2max} = E_{30}(1 - 0.23|\sin\Delta\varphi|)$ due do phase detuning $\Delta\varphi = -\pi/2 + 2\pi N/3 - \varphi_{20}$. Numerical results confirm this analytical estimation. For example, if phase deviation is in the order of 0.1 rad, the maximum amplitude reduces by 10% (see attached Fig.). The effects of absorption and phase mismatches were also investigated.



Secondly, we analyzed the process of giant parametric soliton formation due to group velocity mismatching and interference of the two channels.

References:

1. M. V. Komissarova, A. P. Sukhorukov and V. A. Tereshkov, Bull. Rus. Acad. Sci., Phys. Ser., **61**, 2298 (1997).
2. O. Pfister, J. S. Wells, L. Hollberg, L. Zink, D. A. Van Baak, M. D. Levenson and W. R. Bosenberg, Opt. Let., **22**, 1211 (1997).

WO3

SELF-TRAPPING AND INTERACTION OF SLOW PARAMETRIC SOLITONS

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Parametric solitons due to quadratic nonlinearity were predicted in 1974 and observed in 1995 [1]. Excitation of gap parametric solitons, or simultons could be arranged in the media with two dispersion curves with a non-transmission gap between them. In this case we excite slow soliton with SH $\omega_2 \approx \omega_*$ and two FF waves $\omega_1 = \omega_2/2$ with contrary-oriented wavevectors $k_{11} \approx -k_{12}$ (Fig. 1). The envelopes of these waves are found to obey [2]:

$$\frac{\partial B_2}{\partial t} = iD_2 \frac{\partial^2 B_2}{\partial z^2} - i(\omega_2 - \omega_*)B_2 + i\beta_2 B_{11} B_{12}, \qquad \frac{\partial B_{11,12}}{\partial t} = iD_1 \frac{\partial^2 B_{11,12}}{\partial z^2} - i(\omega_1 - \omega_*)B_{11,12} + i\beta_1 B^*_{12,11} B_2,$$

$D_{1,2}>0$ are the dispersion coefficients, $\beta_{1,2}$ are the coefficients of quadratic nonlinearity. To examine the tunneling we consider $B = A(\xi)\exp(-iqz)$, where $\xi = (z - vt)$. The velocity of soliton: $v^2 = 4D_1\left[(2\omega_* - \alpha\omega_*)/(4-\alpha) - \omega_1\right]$, $\alpha = D_1(\omega_2 - \omega_* + D_2 q_2^2)/D_2(\omega_1 - \omega_* + D_1 q_1^2)$. If two harmonics have equal widths, $\alpha = 1$, we found an sech^2 soliton solution [2].

The investigation of the phenomenon was performed numerically. In particular, we found the regime of gap soliton generation by crystal irradiation with FF CW only. The parameters and time intervals of solitons are close to each other. The peak intensity of propagating solitons is approximately 10 times higher than that of input signal. Numerical experiments showed a regime of soliton collision with interflow into one soliton-like impulse with noticeable amplitude oscillations. By simulation of boundary tunneling of underthreshold soliton-like pairs we found the possibility of soliton formation, these solitons oscillate along the propagation.

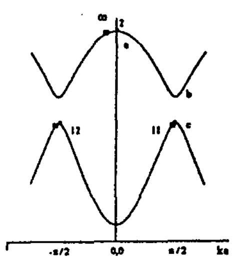

Fig. 1. Two FF waves (11) and (12) excite a SH (2). Squares show the excitation of a slow soliton.

References

1. Schiek R., Baek, Y. and Stegeman, G. I. (1996) // *Phys. Rev. A* 53, 1138-1141.
2. Polyakov, S. V. and Sukhorukov, A. P. (1997) // *Izv. RAN* 12, 2353-2358.

WO4

SPIRALING OF SPATIAL QUADRATIC SOLITONS

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The interest to non-planar interaction of spatial solitons was carried out recently. Experimental results demonstrating spiraling of two photorefractive solitons [1] and theoretical research about non-planer collision of two quadratic solitons [2] have been reported. In the present paper we investigated the soliton spiraling in quadratic nonlinear medium. The coupled NLS equations have been solved numerically for non-planar interaction of two coherent input solitons under different angular momentum.(Fig. 1, 2)

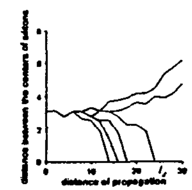


Fig. 1. (l_d is diffraction length of beams)

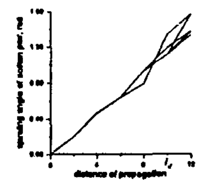
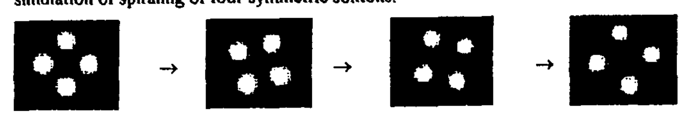


Fig. 2

The soliton ~~spiraling~~ ~~can happen also for tree,~~ four or more solitons, Fig. 3 is numerical simulation of spiraling of four symmetric solitons.



$z = 0$ $\quad$ $z = 4l_d$ $\quad$ $z = 8l_d$ $\quad$ $z = 12l_d$

Fig. 3. Spiraling of four solitons, z - distance of propagation.

The results of our numerical experiments showed, that the spiraling of soliton pair is stable on finite distance (about 10 diffraction lengths), this effect can be used for non-planar switching or rotation of laser beams.

Reference

1. Shih Ming-feng, Segev M., Salamo G.(1997)// *Phys. Rev. Lett.* 78(13), 2551-2554.
2. Steblina V. V., Buryak A. V., Kivshar Yu. S.(1998)//*Opt. Lett.* 23(3), 156-158.

WO5

SELF-ACTION DYNAMICS OF 2D WAVES IN CUBIC NONLINEAR MEDIA

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In a present paper we consider nonlinear propagation of pulsed optical beam. We investigate temporal-spatial self-action, when pulse decompression influences on the beam self-focusing.

The equation for the envelope of temporal modulated beam, propagating in dispersive nonlinear medium is given by

$$i\frac{\partial A}{\partial z} + D_1\frac{\partial^2 A}{\partial x^2} - D_2\frac{\partial^2 A}{\partial \tau^2} + \gamma|A|^2 A = 0, \qquad (1)$$

where $D_1 = 1/(2k)$ is the diffraction coefficient, $D_2 = -(1/2)(\partial^2 k/\partial\omega^2)_{\omega_0}$ is the dispersion coefficient of group velocity $v = (\partial k/\partial\omega)^{-1}_{\omega_0}$, $\tau = t - z/v$, γ is the cubic nonlinearity coefficient.

We derived from (1) a set of two coupled equations for pulse and beam widths f_t, f_r. The analysis of an exact analytical solution with the nonlinearity parameter $\alpha >> 1$ $(\alpha = 2\gamma E_0^2)$, shows that the beam width achieves minimum value $f_{r\,min} = 0{,}83/\alpha$ at the distance $z_{min} = 1{,}18/\sqrt{\alpha}$; in this case $f_t(z_{min}) = 1{,}668$. Equation (1) has been also solved by numerical methods. The results of the simulation were shown in Fig. 1 $(\alpha = 10,$ $z = 0.275)$.

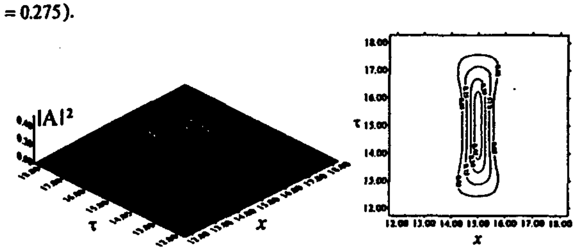

Figure 1. Competition of planar beam self-focusing and pulse decompression.

WO6

SOLITON-LIKE PULSES IN A SYSTEM WITH NONLINEAR GAIN IN THE CASE OF ANOMALOUS OR NORMAL DISPERSION

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Soliton propagation in the presence of spectral filtering is unstable because of the growth of linear radiation. To reduce this instability, it was proposed to use sliding-frequency filters, or, alternatively, to use a combination of linear and nonlinear gain. In this paper we analyze the properties of the soliton propagation in the presence of spectral filtering, linear and nonlinear gain, considering both the anomalous and the normal dispersion regimes. The nonlinear gain that is proportional to the second power of the soliton amplitude is included in the generalized nonlinear Schrödinger equation and the corresponding analytical solutions for the stationary pulse, including fixed-amplitude, arbitrary-amplitude, and chirp-free solutions, are examined. However, we show that to suppress the background instability it is necessary to use nonlinear gain that is proportional to the fourth power of the soliton amplitude, and to satisfy some well defined conditions relating the spectral filtering, the linear gain, and the two types of nonlinear. We present an analytical expression for the steady state fixed-amplitude soliton solution in this case and discuss its domain of validity. The stability of the steady-state solution is analyzed by numerically solving the evolution equations for the soliton amplitude and frequency in the phase-plane formalism. By changing parameters of the system, this soliton can evolve towards a flat-top pulse and eventually split into two fronts. We discuss also a class of soliton solutions with arbitrary amplitude, which exist on special lines in the parameter space where solutions with fixed amplitude become singular. These solitons correspond to stable pulses which propagate in a stable background. A comparison of the characteristics of the pulses as a function of the magnitude and sign of the group-velocity dispersion is also made.

WO7

QUADRATIC SOLITONS WITH HIGH-ORDER DISPERSION

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To describe ultra-short pulses propagation it is essential to take into account higher order dispersion. Such theory was built for solitons in qubically nonlinear media [1,2]. In this paper the properties of parametrically coupled solitons in quadratic media [3] are studied taking into account linear third order dispersion and nonlinear interaction dispersion.

Interaction of the three waves $E_j = A_j(\tau, z)\exp(i\omega_j t - ik_j z)$, where $j = 1,2,3$, $\omega_3 = \omega_1 + \omega_2$ and $\Delta k = k_3 - k_1 - k_2$, is described by the following equations:

$$\frac{\partial A_j}{\partial z} + \nu_j \frac{\partial A_j}{\partial \tau} = iD_j \frac{\partial^2 A_j}{\partial \tau^2} + G_j \frac{\partial^3 A_j}{\partial \tau^3} - i\beta_j W_j - \gamma_j \frac{\partial W_j}{\partial \tau}, \quad (1)$$

where $W_{1,2} = A_3 A_{2,1}^* \exp(-i\Delta k z)$, $W_3 = A_1 A_2 \exp(i\Delta k z)$ are nonlinear terms, D_j and G_j are second and third order linear dispersion coefficients respectively, β_j are nonlinear coefficients, γ_j is nonlinear dispersion coefficient. The envelops $A_j = B_{0j}\left[a + \mathrm{sech}^2((\tau + \alpha z)/T)\right]$ for bright $(a = 0)$ and dark $(a = -2/3)$ solitons were examined. The peak amplitude values equal to $B_{03} = \left(-6/T^2\right)\sqrt{D_1 D_2/\beta_1\beta_2}$ and $B_{01,02} = \pm\left(6/T^2\right)\sqrt{D_{2,1} D_3/\beta_{2,1}\beta_3}$; soliton duration is $T^2 = 4\left|(G_j - G_l)/(\nu_j - \nu_l)\right|$ under $G_j\gamma_j = D_j/\beta_j$. The soliton propagation velocity depends on its amplitude (if $\nu_j = 0$, the velocity addition is $\alpha = 4G_j/T^2 \propto B_{0j}$).

The dispersion of stationary waves with unmodulated envelopes is also analyzed.

References:

1. A. Hasegava, *Optical solitons in Fibers* (Berlin: Springer-Verlag, 1989).
2. E. M. Gromov and V. I. Talanov, Bull. Acad. Sci. Phys. Ser. (12). 16 (1966).
3. A. P. Sukhorukov, *Nonlinear wave interactions in optics and radiophysics* (Nauka, Moscow, 1988).

WO8

Hysteresis reflection of a powerful plane light wave under the oblique incidence on a semi-infinite dense resonant medium

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We consider the light reflection from a dense resonant medium that has the property of the intrinsic optical bistability because of the dipole-dipole interaction of two-level atoms. The incidence angle is assumed to be changeable from zero up to values corresponding to the grazing regime. Earlier it has been shown that the intrinsic optical bistability causes the hysteresis reflection under the normal wave incidence [1,2]. The oblique incidence contributes some special features which are of principle. For example, there emarges the distinction in the hysteresis reflection between the cases of TE- and TM - polarisation (with respect to the incidence plane). If the electrical field has both the TE - component and TM - one, then, in principle, the hysteresis of the elliptical field polarisation of the reflected wave is possible.

Bistable effects in the reflection correlate with the change of the the thickness of the near-surface layer (domain) with the high-level excitation, which emerges as a result of the first-kind phase transition.

[1] V.A. Malyshev, E. Konehero Harke, Opt. Spektr.,84 (4), 630 (1997).
[2] A.A.Afanas'ev, R.A.Vlasov, V.M.Volkov and N.B.Gubar, JOSA B, 84 (3), (1998).

WO9

OPTICAL NONLINEARITY OF NEMATIC LIQUID CRYSTALS DOPED WITH MONOAZO-, DIAZO- AND ANTHRAQUINONE DYES

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Experimental method for determination of the sign of light induced dielectric constant $\delta\varepsilon = \varepsilon_2|\mathbf{E}|^2$ in nematic liquid crystals (NLCs), based on light beam aberrational self-action, has been developed. Detailed investigation of properties of nonlinearity parameter ε_2 in homeotropic and planar NLC samples doped with monoazo-, diazo- and anthraquinone dyes has been carried out.

For azodye doped NLCs the sign of ε_2 was shown to change from negative to positive one at increasing of angle α formed by light wave vector **k** and director **n**. The value of ε_2 may be two orders higher than "giant" orientational nonlinearity of pure NLC. For anthraquinone dyes the nonlinearity sign is negative and independent upon α.

Polarizational dependence of nonlinearity sign was found out for azodyes. It is explained by change of azomolecule properties at photoinduced conformational transitions.

It is established that orienting action of external quasistatic electric field, depending upon experimental geometry, can both increase and suppress the nonlinearity as well as change its sign. The data obtained indicate to absence of remarkable role of photoionization.

Influence of light beam power on the sign of ε_2 and bistability effect were found out. These phenomena are explained by NLC order parameter variation at light heating.

WO10

ON NONLINEAR INTERACTION OF LIGHT WAVES IN NONCONDUCTIVE CHIRAL MEDIUM: OPTICAL RECTIFICATION, POCKELS' EFFECT AND CUBIC NONLINEARITY

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The new spectroscopic techniques based on second order dipolar nonlinearity susceptibilities $\hat{\chi}^{(2)D}(\omega_a;\omega_b,\omega_a-\omega_b)$ have been developed lately[1,2].These techniques can deliver more spectroscopic information and are highly sensitive to the chiral component of homogenous isotropic solutions of biomolecules. Here we report the results of the theoretical investigation of four waves mixing in a chiral solution taking into account Optical Rectification(OR), Pockels' Effect(PE) and third dipolar nonlinearity. OR in chiral solutions should be detected under the condition that the frequencies of the interacting light waves are within the resonance band.

The interaction scheme of quasi-monochromatic plane waves is considered to be the following: l is the width of the chiral layer in the direction y and the medium spreads infinitely in the xz plane. The forward wave **E** and backward wave **E'** propagate along the positive and negative directions of axis y respectively. The constant external electric field $\mathbf{E_0}$ is parallel to axis y. We assume the chiral medium to be slightly nonlinear and slightly absorbing one with the slight spatial dispersion. The account is based on the expansion into normal waves with slowly varying amplitudes:

$$\mathbf{E} = A_+(y)\mathbf{e}_+\exp(-i\omega t + ik_+z - \delta_+z) + A_-(y)\mathbf{e}_-\exp(-i\omega t + ik_-z - \delta_-z)$$

$$\mathbf{E}' = A'_+(y)\mathbf{e}'_+\exp(-i\omega t + ik'_+z - \delta'_+z) + A'_-(y)\mathbf{e}'_-\exp(-i\omega t + ik'_-z - \delta'_-z),$$

where the unit polarization vectors are written as $\mathbf{e}_\pm = \mathbf{e}'_\mp = (\mathbf{e}_x \mp i\mathbf{e}_y)/\sqrt{2}$. $k_\pm, k'_\pm$ are wave vectors and $\delta_\pm, \delta'_\pm$ are dumping coefficients for the normal waves of the consequent polarization, obtained with taking into account the Linear Gyrotropy(LG),Circular Dichroism(LCD) and Linear Absorption(LA),and PE in the external field as well.

The derived equations for the complex amplitudes of normal waves describe their behavior(as a function of y) caused by OR and third order nonlinearity. The analysis is given for several particular cases of nonlinear interaction of waves in different polarization schemes. The analytic solutions are abtained. For the general case the system of differential equations is solved by means of numeric calculations.

* Research fellow is at the Physics Department of Moscow State University.

1. N.I.Koroteev,Zh.,Eksp. Teor. Fiz.,106,1260(1994).
2. T.M.Il'inova, N.I.Koroteev and N.O.Urakova, Laser Physics,6,1080(1996).

WO11

FLOWER-LIKE PATTERNS AND SPATIAL LOCALIZED STRUCTURES IN NONLINEAR RING RESONATOR

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We study theoretically and numerically pattern formation processes in a passive nonlinear ring resonator with thin layer of Kerr-type nonlinearity medium. Our mathematical model takes into account local transverse interactions caused by diffusion of the nonlinear medium particles and diffraction of the light in the resonator. To check the theory we carried out numerical simulation. Dynamics of nonlinear cavity is not limited by the oclassicaln spatial patterns such as roll, hexagon, dodecagon and rhombus [1], but it proves to be more rich. We found that the average phase of intracavity field may essentially influence the pattern formation process. This phase may increase, as an amplitude of transverse spatial structure grows. Thus the higher excitation areas may be involved into the interaction. It results in formation of very complicated and beautiful transverse patterns that we call flower-like patterns. Earlier such patterns have not been seen in nonlinear ring cavities.

Also the new dynamic regime has been found numerically. This regime results in formation of spatial localized structures ~~in the~~ resonator. Recently such structures have been observed in many nonlinear systems [2]. In our case the localized structure occurs in bistable region of the steady-state curve near the excitation threshold. It has a form of drifting bright large spots in a transverse cross-section of intracavity field. These spots can join each other, disappear and appear again. Spots exist on pale small spatial structure (usually, hexagon). We showed, that there is quite narrow area of input intensity where localized structure can form, and described the mechanism of the formation process. We observed several types of spatial localized structures.

1. Vorontsov M.A. and Karpov A.Yu., J. Opt. Soc. Am. B v.14, N1, p.34, 1997.
2. Brambilla M., Lugiato L.A., and Stefani M. Europhys. Lett., v.34, N2, p.109, 1996.

WO12

POLARIZATION INSTABILITIES AT THE INTERACTION OF COUNTERPROPAGATING WAVES IN TWO-PASS OPTICAL SYSTEM WITH A NONLINEAR MEDIUM AND A ROTATABLE MIRROR

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We have advanced in the theoretical investigation of the stability of stationary field states inside a relatively simple optical system, consisting of a rotatable mirror and an isotropic Kerr medium without absorption placed immediately in front of it. In steady-state regime the intensity I and the ellipticity B of light at the entry and exit from this system are identical and the angle of rotation of the polarization ellipse of the output radiation exhibits a multivalued dependence on I and B.

In the all-important case of the identical linear polarization of counterpropagating waves we have obtained a transcendental equation for the Lyapunov factor which characterizes the increase of arbitrarily elliptically polarized plane perturbations. The analytical investigation of it indicates that for $\gamma = \chi_1/\chi_2 > -2$ (independent parameters χ_1 and χ_2 fully determine the tensor of the cubic nonlinearity) the stationary state of the field under study loses stability with $I \geq I_0$, and the optical system goes over into one of two new stationary field states arising at $I = I_0$. With $\gamma \leq -2$ the stationary state of the field under study is the only possible one for any intensities of incident linearly polarized light [1]. Its instability at some values of I means that at these I there occurs a complex regime of variation in the polarization characteristics of output radiation such as self-oscillations or even dynamical chaos. We have found the analytical expressions for the boundaries of the regions on the plane of I and γ corresponding to such regimes.

1. A. A. Golubkov, V. A. Makarov, Sov. J. Quantum. Electron., **21**, 1133 (1991).

WO13

TRANSITION TO CHAOS IN INTERFEROMETER WITH AMPLITUDE-PHASE NONLINEARITY

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The origin conditions and characteristics of complex dynamic operating modes have been analyzed for an interferometer with resonance nonlinearity. The conditions of light pulse generation have been determined at the interferometer output for constant input intensity. Consideration has been given to resonant media modeled by three- or four-level schemes of the molecular energy states.

It has been shown that changes in the intensity at the interferometer output are due to concurrent effects of phase and (or) amplitude nonlinearity components on the interferometer transmission when different excited states of molecules are populated. The conditions of transition to chaotic oscillations have been explicitly determined for a four-level medium model with the use of Shilnikov's theorem. The influence of positions of absorption and emission bands, probabilities of spontaneous and radiationless transitions on the origination conditions of a strange attractor have been treated. It has been demonstrated that in the vicinity of multipass Shilnikov's attractor the transition to chaos takes place. Transition to chaos may be also realized through selection of the interaction parameters, for which a sequence of the period-doubling bifurcations is the case. It has been demonstrated that the possibility exists of generating regular oscillations that are complex in form, and generating a specified number of single pulses. The dynamic system in this parameter domain is very sensitive to changes in external conditions making it possible, among other things, to provide an effective control of the oscillation frequency and form for small changes in the radiation intensity at the input of interferometer.

WO14

NON-LINEAR TRANSFORMATIONS OF OPTICAL VORTICES

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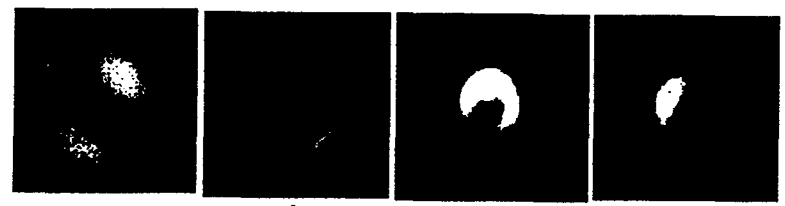
Nye and Berry established the existence of branch-point phase singularities in electromagnetic wave fields in 1974 [1]. Nowadays the phenomenon is usually known as an optical vortex. The parametric interactions may provide an efficient way of vortex transformation:



a b c d

It is demonstrated, that optical parametrical amplifier (OPA) enables to produce a vortex with opposite topological charge (to reverse vortex). Figs. a, b, show the signal and idler waves, respectively, at the output of the OPA after passing through the cylindrical-lens analyser (pump wave 355 nm; signal wave 1064 nm, e-polarisation; idler wave 532 nm, o-polarisation). The signal and idler wave contain vortices with opposite charges.

The spatial distributions of the second harmonic field of the beam with vortex are presented in Figs. c, d for a different length of the KDP crystal (4 and 6 cm). Two zeroes in the field distribution is the result of the decay of second order vortex into two vortices of first order inflicted by walk-off in non-linear medium.

References:

1. J.F.Nye, M.V.Berry, Proc. R. Soc. London A336, 165 (1974).

WO15

HOW IS IT POSSIBLE TO OBSERVE THE INFLUENCE OF THE LIGHT TRAJECTORY ON THE POLARIZATION IN THE HOMOGENEOUS MEDIUM

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The observation of an optical Magnus effect [1] has given rise to the development of the new field of modern optics concerned with the mutual influence of the light trajectory and the polarization. Optical Magnus effect can be regarded as a consequence of the optical inhomogeneity of a medium or the breakdown of the translation symmetry of a medium.

As for the homogeneous medium, the influence of the polarization on the light propagation has been observed as well [2]. That effect can be considered as the manifestation of spin-orbit interaction of a photon, so the inverse effect should exist. We suppose that the spin-orbit interaction of a photon is due to the breakdown of axial symmetry of space. That approach to the problem of the origin of the spin-orbit interaction of a photon enables us to find the inverse effect.

We propose the following scheme for the observation of the influence of the light trajectory on the polarization. Let us illuminate the left half ($y > 0$) of an optical lens by a plane linearly polarized wave with the wavelength λ. The linearly polarized wave may be regarded as a superposition of right-handed and left-handed circularly polarized waves. The "centers of gravity" of right-handed and left-handed circularly polarized light will be spaced at interval $\Delta x \sim \lambda$ at the focal spot [2]. Let us screen the upper part of the focal spot ($x > 0$), then the state of polarization of the light observed trough the collimator will differ from the linear. The value (and the sign) of ellipticity will depend on what part of the focal spot is screened. We estimated ellipticity (attributed to intensity) to be $\sim 10^{-4}$.

The experimental method for investigation of polarized light with such a low ellipticity was proposed and realized. Preliminary experimental investigation reveals the dependence of the ellipticity on the screen edge position x. That result is supposed to indicate the existence of the inverse effect.

[1] Dooghin A.V., Kundikova N.D., Liberman V.S., Zel'dovich B.Ya. *Physical Review* A, **45**, 8204 (1992).
[2] N.D.Kundikova, F.V.Podgornov, L.F.Rogacheva, B.Ya.Zel'dovich. *Pure and Applied Optics*, **4**, 179 (1995).

WO16

The Interplay between Diffraction and Diffusion: A Study of the Effects Influencing Temperature Induced Absorptive Optical Bistability

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SUMMARY

We present a systematic numerical simulation of intrinsic optical bistability induced in a semiconductor-doped glass filter by an incident gaussian beam. Using a Fast Hankel Transform technique [1], we include both longitudinal and transverse heat diffusion [2], allowing us to quantify the effects of self-focusing and a non-uniform absorption coefficient on the beam propagation within the medium. We explicitly examine the case for which the sample thickness is comparable to the incident beams confocal distance, so that both heat diffusion and beam diffraction within the sample are important.

The simulations are compared to recent experimental results obtained with a commercially available doped glass filter (CdS_xSe_{1-x}) using the 514.5 nm line of a continuos Argon ion laser. An incident power of 100 mW focused down to a spot size of 16 µm is sufficient to induce bistable switching. The bistable transmission pattern was observed as a function of the sample position relative to the incident beam waist in a modified form of the Z-scan technique. Simultaneously we monitored the induced changes in the optical thickness of the sample through the "Fabry-Perot" interference fringes due to reflections from the first and second uncoated surfaces of the doped glass filter.

Through our simulations we are able to conclude that significant self-focusing occurs within the sample – for sample positions near the beam waist, the existing beam is nearly 30% smaller than if would be if there were no temperature induced refractive index gradient within the sample. Curiously we find that a radially varying absorption coefficient leads to significant focusing for an incident diverging beam, while being relatively unimportant for an incident converging beam.

References:
1. A. E. Siegman, "Quasi Fast Hankel Transform", *Opt. Lett.*, Vol. 1, pp.13-15, 1977
2. W. D. St. John, J. P. Wicksted and G. Cantwell, "Transverse Structures in Resonatorless Absorptive Switching in bulk ZnSe", *J. Appl. Phys.*, Vol. 73, pp.3013-3017,1993.

WO17

SPHERICAL STRUCTURAL RESONANCES SELF-LOCALIZED IN A NONLINEAR MEDIUM

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There is a major interest in the generation and scattering of laser radiation by spherical microparticles [1]. We consider a nonlinear self-interaction of a three-dimensional spherical structure of an electromagnetic field in a homogeneous isotropic medium with a cubic nonlinearity. Spherical soliton-like states satisfying finite values of total energy can be realized at an initial permittivity $\varepsilon_0 < 0$. The spherically symmetric radial-gradient distribution of the refractive index induced under these conditions can act as a microcavity. The total internal reflection and positive values of induced permittivity inside this cavity ensure the existence of undamped spherical modes known as structural resonances [2]. All modes are localized near the center at a distance of several wavelengths. The number of spherically-concentric region where the field can exist as undamped electromagnetic waves depends discretely on the total energy magnitude saved in a set of spherical modes.

The role of self-influence potential and the stability of structural resonances are also discussed. The analysis based on the quantum-mechanical analogy shows to realize classically allowed local states of the field $\mathcal{E}_l$ the intensity has to satisfy the following condition: $\varepsilon_2|\mathcal{E}_l|^2 > |\varepsilon_0| + l(l+1)(c/\omega r)^2$. The fulfillment of this condition provides the existence of undamped spherically-localized modes caused by negative values of total potential in a potential well's region.

1. *Optical Effects Associated with Small Particles,* P.W. Barber, and R.K. Chang, Eds. Singapore: World Scientific, 1988.
2. V.V. Kabanov, *Quantum Electronics,* **26,** 820, 1996.

WO18

PHASE CONJUGATION AT INTRACAVITY DFWM OF FREQUENCY SELECTIVE PULSED CO LASER RADIATION

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Energetic, temporal and spectral characteristics of the phase conjugation (PC) process at intracavity degenerate four wave mixing (DFWM) of frequency selective pulsed e-beam controlled discharge (EBCD) CO laser radiation are studied both experimentally and theoretically. Laser mixture $CO:N_2:He=1:4:5$, density 0.3 Amagat, 120-140 K, interaction angle at DFWM ~10 mrad, active length 1.2 m, resonator length 17.7 m. PC reflectivity (PCR) on energy is ~1%, being independent of specific input energy. The dependencies of PCR on pressure have quite different behavior for different selected spectral lines. An influence of lasing on the neighboring vibrational bands on PCR for the spectral line under the investigation is demonstrated, PCR decreasing at switching on neighboring line lasing.

The numerical model is formulated to simulate the temporal behavior of PCR on the transmission gain (amplitude) and refraction (phase) gratings formed in the active medium of pulsed EBCD CO laser. On the first stage of numerical procedure the temporal behaviour of amplitude and phase gratings is modeled using a comprehensive model of the laser, solving the complete set of vibrational and electron kinetics equations. On the second stage PCR is calculated both numerically and analytically. This model is applied for simulation of real experimental setup characteristics. The obtained data have temporal behaviour analogous to experimental measured ones, the theoretical PCR being higher as compared to experimental one. Some physical mechanisms responsible for this discrepancy are analyzed.

WO19

Nonlinear optical properties of turbulent gas flow in FAF CO_2 laser.

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The turbulent flow of the laser gas mix being in the state of thermodynamic nonequilibrum was under investigation to determine its statistical characteristics. Two methods complementing each other, namely, the local luminescent method and the dual beam shear interferometry, were used to determine the spatial and temporary characteristics of high-speed (up to 200 m/sec) turbulent flow of the laser mix of the low pressure (near 70 mbar) in the discharge tube of limited cross size. The special data acquisition system based on Pentium PC including analog- to- digital converters was used. The values of gas density fluctuations, their spatial scales and frequency characteristics were determined. The obtained dependence of fluctuation value on its spatial scale has a kind of Obuchov - Kolmogorov characteristic typical for turbulence, which is indicative of the turbulent nature of the observed nonuniformities of gas density and, accordingly, of the refraction index. The degree of thermodynamic nonequilibrum of the gas flow was varied changing the discharge current in the tube. By this means the statistical characteristics of turbulence in the high-speed flow of vibrationally excited laser mix and their dependence on heat release rate were analyzed under conditions of limited VT-relaxation. These measurements were carried out in the absence and under intense laser radiation. As the result, the influence of laser radiation on the statistical parameters of turbulent flow of the laser mix was revealed, that is explained by the nonlinear character of heat release in the laser mix. The wave- front distortions of the probe beam caused by small-scale optical nonuniformities of the turbulent origin and their nonlinear component were also determined on the basis of the obtained data.

WO20

NONLINEAR OPTICAL PROPERTIES OF ACTIVE MEDIUM AT INTRACAVITY DFWM OF PULSED CO_2 LASER RADIATION

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Nonlinear optical properties of the active medium of pulsed e-beam controlled discharge (EBCD) CO_2 laser at phase conjugation (PC) under intracavity degenerate four-wave mixing (DFWM) are studied both experimentally and theoretically. The experiment is carried out with the following reference parameters: laser gas mixture CO_2:N_2:He=1:2:4, 0.3 atm, active medium length 1.2 m, resonator length 12 m (17.7 m for single line laser), interaction angle ~10 mrad at DFWM without optical delay between probe wave E_3 and co-propagating pumping one E_1. PC reflectivity (PCR) on energy strongly depends on such parameters as: specific input energy; intensity ratio for E_3 and E_1; coherency of the laser radiation, that varied by rotation of mutual polarization or with optical delay between E_3 and E_1; geometry of DFWM; Q-factor of laser resonator, which changed with output coupler R_{out} (8-80%), PCR is maximal with R_{out} of 8% but best optical quality of PC signal is observed with R_{out}=80%; laser gas mixture content and pressure, being maximal for mixture with low content of helium and at higher pressure (up to 0.6 atm). A periodical dependence of PCR on optical delay between E_3 and E_1 with periods 10^{-3} and 10^{-5} m is observed. The PCR do not depend on spectral content and a degree of linear polarization of the laser radiation.

The numerical model of active medium of a pulsed EBCD CO_2 laser is formulated to simulate the temporal behavior of PC signal at intracavity DFWM on the large-scale gain and thermal gratings formed in the active medium of the laser. Comparison of the theoretical and experimental data is discussed.

WO21

TERMOOPTIC DISTORTIONS FOR SHG IN NONLINEAR CRYSTALS UNDER CONSIDERATION OF ELASTOOPTIC PHENOMENA.

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During the second harmonic generation (SHG) *the lasers with significant average* power are used. It results to thermal self-actions in nonlinear crystals (NC). The task about their influence on SHG is reduced to the joint solving of equations for complex amplitudes and also termoconductivity and termoelasticity equations. The absorption of radiation causes a non-uniform temperature field in cross section of NC that results in change of refraction indexes of interacting waves (termooptic distortion): $\Delta n = \Delta n_T + \Delta n_\sigma$, where $\Delta n_T = \left(\frac{\partial n}{\partial T}\right)_{\sigma=0} \cdot \Delta T$, and Δn_σ – change due to termoelasticity stresses σ_{ij} (elastooptic distortion). We carried out the analysis of elastooptic distortion during the SHG for NC in cylindrical form with a stationary parabolic temperature field which corresponds stationary SHG with homogeneous intensity of input basic radiation. With account of expressions for termoelasticity stresses σ_{ij} we considered character of change of wave vector mismatch $\Delta k(x_1', x_2')$ in NC cross section for uniaxial nonlinear crystals of classes 4mm, $\bar{4}$2m, $\bar{4}$, 32, 3m, $\bar{6}$m2, 6mm and 6. It is shown that with account of elastooptic effect the surface $\Delta k(x_1', x_2')$ is elliptic or hyperbolic paraboloid which in general case have arbitrarily orientation. It is also shown that for negative crystals of classes $\bar{4}$2m, 3m, $\bar{6}$m2, 6mm and positive crystals of classes $\bar{4}$2m, 32, $\bar{6}$m2, with orientation NC corresponded a maximum of effective nonlinearity $|d_{\text{эфф}}|$ for scalar phase-matching of the first type the expressions for σ_{ij} are simplified and the surface $\Delta k(x_1', x_2')$ will be symmetric with respect to main plane. For crystals *ADP*, *$LiNbO_3$* and *KDP* in fixed-field approximation the wave mismatch and efficiency of SHG with account of elastooptic distortion are calculated.

WO22

Mode locking and pulse shortening by nonlinear mirror based on type II frequency doubling crystal

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We investigate a new type non-linear mirror called by us Type II non-linear mirror. It consists of: a polirizer, a non-linear crystal aligned for imbalance Type II second harmonic generation and back reflection coefficient at fundamental wavelength R_ω. The distance between the non-linear crystal and the back reflector can be changed for the purpose of optimization of the phase difference between the fundamental waves and the generated second harmonic $\Delta\Phi_{add}$ for the second pass through non-linear crystal.

Intensity dependent reflection coefficient for this type non-linear mirror can be explained as follows. The input fundamental wave is split in the non-linear crystal and forms two eigen waves with perpendicular polarizations ("o" and "e" wave). The amplitudes of the two eigen waves have to be different and this is achieved by proper orientation of the non-linear crystal. Due to the fact that the two eigen waves have different phase velocities inside the crystal at low input intensities (when second harmonic generation process is very inefficient), the non-linear mirror has reflection coefficient at fundamental wavelength lower that R_ω, i.e. $R_{NL} < R_\omega$. At higher input intensities the two eigen fundamental waves after two passes through the non-linear crystal, tuned close to the phase matched condition, collect different in value non-linear phase shifts. The non-linear phase shift compensates the constant phase shift introduced by the birefringence of the crystal, leading this way to an increase of the reflection coefficient at fundamental wavelength. The value of R_{NL} depends on the input intensity. The higher the input intensity the higher R_{NL}. When this nonlinear mirror is used as a laser mirror the effect is equivalent to a positive feedback for the laser itself. Consequently, type II nonlinear mirror can be used as an intracavity mode-locking and pulse shortening device. The additional advantage of this type II non-linear mirror, from the point of view of its application for mode locking is the additional substantial pulse shortening in the saturation stage of the laser gain coefficients.

WO23

DISSIPATIVE LOCALISED STRUCTURES OF LASER RADIATION

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Stable dissipative localised structures in wide-aperture laser systems present spots of lasing on the background of nonlasing mode in the system cross section. They were predicted [1] and investigated [2-5] in wide-aperture lasers with intracavity saturable absorption and in continuous media with saturating gain and losses. In the report a review is given of results of recent theoretical and experimental investigations of these structures promising for applications to information processing.

The laser system is described by parabolic equation for the electric field envelope and Bloch equations for the two media polarization and population difference. In the limit of small relaxation times of media a single parabolic equation results – the generalized complex Ginzburg-Landau equation. Depending on the scheme, 1D, 2D and 3D structures are described by this equation. For 1D localised structures, bifurcation and stability analysis of stationary single and coupled structures is presented. It is shown that with increase of pumping stationary localised structure loses its stability, and pulsing localised structure arises; with further increase of pumping more complex modes up to chaotic ones are present. There are stable 2D localised structures with different values of topological index. Possibility of 3D localised structures (the "laser bullets") is also shown.

Effect of relaxation times was studied for 1D laser structures. Bifurcation between motionless and moving in transverse direction structures is found, and scenario of destabilization of the motionless structures is presented.

1. N.N.Rosanov, S.V.Fedorov. *Opt. and Spectr.*, **72**, 1394 (1992).
2. N.N.Rosanov, A.V.Fedorov, S.V.Fedorov, G.V.Khodova. *Proc. SPIE*, **2039**, 330 (1993).
3. A.G.Vladimirov, N.N.Rosanov, S.V.Fedorov, G.V.Khodova. *Quantum Electron.*, **27**, 949 (1997); **28**, 58 (1998).
4. N.N.Rosanov. *Optical bistability and hysteresis in distributed nonlinear systems.* Moscow, Nauka, PhysMathLit (1997).
5. V.B.Taranenko, K.Stalunas, C.O.Weiss *Phys. Rev.*, 1582 (1997).

WO24

PUMP LOSSES IN A PARAMETRIC AMPLIFIER

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Nonequal damping in signal and idler waves has been studied by Zahler and Ben-Aryeh [1] in a nondegenerate parametric amplifier. This analysis was performed within framework of the so-called «undepleted pump» approximation allowing the authors to make various important inferences about effects of losses of the signal and idler waves under parametric amplification. However, it is clear that the losses at the higher, i. e., of the pump, interacting frequency cannot be negligible in such consideration. Otherwise, physical operation of parametric amplifier would be described very distortly.
In this communication, we demonstrate how dramatically the situation changes taking account of, along with losses at signal and idler frequency, only linear damping in the pump field. We construct a solution in the linearly depleted pump approximation and show that this solution «kills» the effect of stabilization and considerably diminishes the oscillation effect both found by Zahler and Ben-Aryehin the constant pump field. On the other hand, the present solution describe well the signal and idler intensities at the actual value of the pump losses.

References

1. M. Zahler and Y. Ben-Aryeh, Optics Comm. 79 (1990) 361.
2. E. Kamke, Differentialgleichungen, Losungsmethoden und Losungen (Akademische Verlag, Leipzig, 1943).
3. A. S. Gorskov, K. I. Voliak, G. A. Lyakhov and Yarovoi, FIAN Preprint No. 112 (Moscow), 1982) [in Russian].
4. A. Yariv and P. Yeh, Optical waves in crystals: propagation and control of laser radiation (Wiley, New York, 1984).

WO25

Interaction between two chaotic laser modes

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The dynamics of a chaotic laser mode consists of two parts: the chaotic amplitude dynamics and chaotic phase dynamics /1/. In the case of a single mode laser, these two parts are uncoupled and equally represent the chaotic character of a laser mode. However, when chaotic modes are phase sensitively coupled, not only the chaotic phase and amplitude dynamics of each mode, but also those between interacting modes couple together. Obviously, interaction between intrinsically chaotic laser modes could be very complicated.

In this paper we report an experimental study on interaction between the two chaotic modes of an optically pumped NH_3 bidirectional ring laser /2/. We have studied their interaction through simultaneously monitoring their amplitude dynamics and their mode beating. Different behaviour of the mode interaction are observed. Generally when the interaction between the modes is incorporated, the coupling results in that the chaotic amplitude dynamics of each mode becomes even more complicated. The chaotic mode amplitude dynamics can become hyperchaotic/3/. Interaction between the modes can also lead to mode locking. Two stages of mode locking exist. Under a relatively weak mode interaction, the average frequencies of the modes can become locked, while their phases still vary chaotically independently.Under average frequency locking, the modes are still distinguishable and strong gain competition exists between them. In this state the chaotic amplitude variations between the modes exhibit a strong antiphase correlation. Under very strong mode coupling, the chaotic phases of the modes can become locked together.Under a phase locking the chaotic intensity dynamics of each mode becomes exactly the same, showing a state of chaotic synchronization.Under the phase locking the chaotic mode intensity dynamics of each mode is that of the single mode chaotic dynamics of the laser.

Mutual frequency entrainment between the average beat frequency of the modes and their intrinsic chaotic mode amplitude pulsation frequencies is possible under the mode coupling. A characteristic of this frequency entrained state is that the frequencies of average chaotic mode intensity pulsations are the same, while their chaotic amplitude dynamics are uncorrelated. The chaotic intensity dynamics of each mode in this state show a close similarity to that of the single mode laser chaotic intensity dynamics.

References:

1. E. Roldán, G. J. de Valcárcel, R. Vilaseca and P. Mandel, Phys. Rev. A, *48*, 591(1993).
1. D. Y. Tang and N. R. Heckenberg, J. Opt. Soc. Am. B, *14*, 2930(1997).
3. O. E. Rössler, Phys. Lett. A, *71*, 155(1979).

WO26

New advances in solid-state powder lasers

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In 1986 Markushev et al. observed a dramatic narrowing of Nd luminescence line ($^4F_{3/2}$-$^4I_{11/2}$) in powder of $Na_5La(MoO_4)_4$. When the pumping energy exceeded some critical threshold value, a series of short (subnanosecond) emission pulses at 1.06 μm appeared in response to a single 30 ns pumping pulse. A short pulsed emission without cavity was later studied in powders of many other solid-state laser materials.

In the present paper we report the results of our recent studies of powder laser emission. (I) We have conducted interferometric measurements of coherence in powder lasers. The characteristic longitudinal coherence length (≈1.7 cm) of $Nd_{0.5}La_{0.5}Al_3(BO_3)_4$ powder laser emission corresponds to the linewidth of ≈0.66 Å. The transversal coherence between two spots on the surface of the powder laser vanishes when the distance between spots is equal to ≈85 μm. (II) A laser-like emission was obtained (at λ≈800 nm) in Ti-sapphire powder and compared to that in $Nd_{0.5}La_{0.5}Al_3(BO_3)_4$. We found that a hole "drilled" in a powder sample by intense focused pumping beam is advantageous for stimulated emission in Ti-sapphire powders and disadvantageous for that in Nd doped powders. We explain this effect by difference in scattering penetration length and effective absorption length in two materials. (III) The effect of the material volume density on the stimulated emission has been experimentally studied in $Nd_{0.5}La_{0.5}Al_3(BO_3)_4$ powder. The slope efficiency of the stimulated emission increases with the powder density. (IV) We have demonstrated the possibility of controlling both the intensity and the wavelength of the powder laser emission with external seeding light. (V) We have obtained a 1.06 μm stimulated emission and its 0.53 μm second harmonic in a mixture of powders of laser ($Nd_{0.5}La_{0.5}Al_3(BO_3)_4$) and frequency doubling (2-methyl-4-nitroaniline) materials under 580 nm pumping. We have developed a model allowing one to optimize 2-methyl-4-nitroaniline concentration for different pumping energies. We believe that our studies lead to better understanding of operation of powder lasers and their new applications.

New magnetooptical effects in anysotropic crystals and methods for their experimental study

W027

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Magnetooptical effects in non-centrosymmetric anysotropic crystals are studied theoretically and experimentally. The generalized phenomenological theory of optical effects of induced anysotropy in crystals is developed which takes into account magneto- and electro-chiral effects, as well as cross-section effects of optical activity and Faraday effect. Corresponding inverse nonlinear effects are considered which manifest themselves as constant magnetization or electrization of a medium induced by optical field. The particular attention is paid to recently discovered magnetochiral effect (MCE) and to corresponding inverse effect. MCE occurs in anysotropic chiral crystals placed into transverse magnetic field, and may manifest itself as nonreciprocal linear birefringence (NLB). As an effect associated with simultaneous temporal and parity symmetry violation MCE is of great interest for modern physics.

The theory of MCE in crystals of different symmetry is developed. It is shown that cross-section effects of optical activity and Faraday effect may mask MCE, and in crystals with large natural birefringence may be comparable with MCE.

The experimental methods of nonreciprocal optics are revised. Ring interferometers of different types as tools for study of nonreciprocal effects are discussed.

To observe MCE in $LiIO_3$ and KDP crystals the new experimental methods are used. Anysotropy of NLB is measured in the range $0.45 \div 0.68\ \mu m$ with new two-pass scheme with two quarter-wave phase plates which allows to get rid of all reciprocal effects as well as Faraday effect. It is found that NLB anysotropy increases with wavenumber faster than Faraday effect and optical activity. Absolute values of NLB in $LiIO_3$ and KDP at $0.83\ \mu m$ is measured with Sagnac ring interferometer with absorbing beamsplitter producing $\pi/2$ initial phase shift of counterrunning waves.

Anysotropy of Faraday effect in crystals with large natural birefringence (α-quartz) is measured with original method in which polarization of o and e waves is measured separately.

Measurement of $\chi^{(2)}$ components by comparing polarization resolved second order cascade processes

W028

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Cascade THG proves to be a versatile tool probing the sign and value of all second order nonlinear tensor components. Generally the $\chi^{(2)}$ tensor form will allow all six types of effective nonlinearity, although only types allowed by dispersion are phase matchable. Cascade THG poses no such a limit to THG along phase matchable directions for SHG and SFG of any type. If all six types of effective nonlinearities are possible then we get for the $F(\beta)$ function [1] for THG, re-solved along the slow "s" and fast "f" directions, the depen-dencies from the table. The angle β stands for the input polarization direction and is measu-red from the "f" polariza-tion direction and

Interaction		THG	$F(\beta)$
$\Delta k_{SHG} = 0$		f	$\sin^4(\beta)[\cos(\beta) + a\sin(\beta)]^2$
$ss \to f$		s	$\sin^4(\beta)[\sin(\beta) + b\cos(\beta)]^2$
$\Delta k_{SHG} = 0$		f	$\sin^2(\beta)\cos^2(\beta)[\cos(\beta) + a\sin(\beta)]^2$
$sf \to f$		s	$\sin^2(\beta)\cos^2(\beta)[\sin(\beta) + b\cos(\beta)]^2$
Δ	ss-f	f	$\sin^2(\beta)[\sin^2(\beta) + c\sin(\beta)\cos(\beta) + d\sin^2(\beta)]^2$
ksFG	fs-f	f	$\cos^2(\beta)[\cos^2(\beta) + c\sin(\beta)\cos(\beta) + d\sin^2(\beta)]^2$
=0	sf-f	f	$\sin^2(\beta)[\cos^2(\beta) + a\sin(\beta)\cos(\beta) + e\sin^2(\beta)]^2$

$a = sff / fff$, $b = sff / ssf$, $c = ssf / sss$, $d = sff / sss$, $e = ssf / fff$, stand for ratios of effective nonlinearities of two second order processes. Each of these functions will generate a typical pattern, very sensitive to the sign and the value of tensor components, provided denominators of these ratios are nonzero values along phase matchable directions. Walk-off angles and wave vector mismatch are a part of these ratios and should be accounted for at appropriate wavelengths. Most notable are the SFG cases that will generate a sixfold dependence when the d and e ratios are negative and a fourfold one when positive. They will always couple non-phase matchable components, whatever the type of SFG is. Discussed are uniaxial and biaxial types, specifically mm2.

1.P.Qiu, A.Penzkofer, Appl. Phys. B 45, 225-236 (1988)

WO29

THE PECULIARITIES OF THE EFFECTS SELF INDUCED TRANSPARENCY IN FERROELECTRIC MEDIUM

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We have studed the propagation of the laser pulse of self induced tranparency in ferroelectric medium. We obtain efficient equations which describe dynamics of the laser pulse presenting itself nonlinear sin-Gordon equation [1]:

$$\varphi_{xx} - \varphi_{\tau\tau} = -\sin\varphi + \varepsilon\hat{P};$$

$$\hat{P} = w_1(\varphi_\tau^2 \sin 2\varphi)_x + w_2 \sin\varphi \int_0^\tau d\tau \varphi_\tau^2 \sin^2\varphi + w_3\varphi_\tau^3;$$

We analyzed action of ferroelectrics proporties of the medium on soliton regime of propagation of the laser pulse. The dependences of the soliton velocity from the time t and temperature of simple T_0 are illustrated in Fig.1a (for paraelectric phase) and in Fig.1b (for ferroelectric phase). Discussed possible physical results of the under study effects.

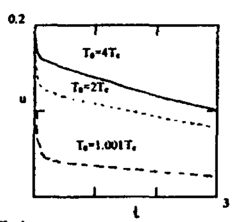

Fig. 1a

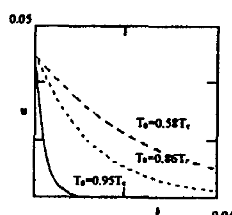

Fig. 1b

1. Belonenko M.B., Kabakov V.V.// Laser Physics, 1997, Vol.7, no. 6, pp. 1197-1201.

WO30

Adaptive loop resonator based on the degenerate four-wave mixing.

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The special method to use the loop scheme for the cavity of the Nd-lasers is suggested. The adaptive properties of the proposed resonator are explained by optical phase conjugation (OPC) due to the four-wave mixing in the bulk of the Cr-doped crystalline passive Q-switch. During the study of the degenerate four-wave mixing in the Cr-doped crystals we observed relatively small values of the reflection coefficient of the OPC-mirrors - not exceeded ~1%. Nevertheless the application of these nonlinear media directly in the loop resonator allows to organize the intracavity compensation of the laser beam distortions and to improve the polarization, spatial and energetic characteristics of the laser output.

We made the simulation which has shown the correctness of the proposed model of the adaptive loop resonator operation. It was shown both theoretically and in the experiment that the four-wave mixing took place on the dynamical holographic gratings of the refraction index forming in the bulk of the Q-switch during the laser pulse build-up.

The results of the experimental study of the properties of the adaptive loop resonator of the Nd-laser are presented.

Polarization steady-states and limit cycle attractors in A vector class-A lasers

WO31

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Polarization behavior of the laser field has recently received sustained attention [1]. This interest is based on the fact that polarization is one of the parameters which increases system's degree of freedom and, as a consequence, an informativeness of the signal. On the other hand, this degree of freedom, i.e., the polarization state, in lasers is governed by its own decay rate which is independent, in many cases, of the intensity decay rate [2]. The new decay rate leads to an important fact that even behavior of class-A vector lasers fully belongs to the problem of nonlinear dynamics. Consequently, the theory of nonlinear dynamics can be used to analyze static and time-dependent regimes of such lasers including the case of a laser subjected to the action of the external magnetic field. In this contribution we report on the results of such rigorous analysis of the structure of the phase space of a class-A vector laser in the simplest case of the cavity linear anisotropy with or without the axial magnetic field applied.

It is analytically found all steady states and bifurcations in a class-A (generally detuned) laser with no magnetic field and is shown that a pitchfork bifurcation is a source of the elliptically polarized states in such a system. For two qualitatively different types of lasers with transitions $J \to J' + 1$ $(J > 0)$ and $J \to J'$ $(J > 1)$ stability analysis reveals the presence of an unstable and a stable limit cycle attractors, consequently, in the phase space. Numerical study of both types of lasers subjected to the action of the axial magnetic field is also performed from nonlinear dynamic viewpoint.

[1] See, for instance, Quantum. Semiclass. Opt. **10**, N 1 (1998), special issue on "Polarization effects in lasers and spectroscopy".

[2] A. Kul'minskii, A. Voitovich, V. Severikov, Quantum. Semiclass. Opt. **10**, 107 (1998).

Investigation of chaotic instabilities in Kerr mode-locked tunable Cr^{4+}:YAG laser

WO32

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We report the results of numerical calculations the steady self-organizing structures of short laser impulses in spatial-temporary phase volume at their nonlinear self-interaction. The optimum configuration of the resonator ensuring reception Kerr lens mode-locking with presence of a strong thermal lens in active media is offered. It is shown, that there is an optimum configuration for Kerr lens ensuring the maximal modulating effect. We investigate of Kerr mode-locked regime in tunable Cr^{4+}:YAG laser. We have obtained mode-locked generation of tunable radiation in the range from 1,350 to 1,550 nm. The Cr^{4+}:YAG - laser has consisted of Cr^{4+}:YAG rod placed into the astigmatically compensated, four mirror cavity. The system of pumping with required quality of a zero Gaussian mode for Cr^{4+}:YAG on a basis of the Nd:YAG laser is developed with output power up to 10 W, instability of output power < 0.7 %, instability on a beam angle < 0.03 mrad. Using a 0.5% transmitting output mirror, as high as 305 mW of useful output power at 1500 nm was obtained from the laser with 5.5 W of absorbed pump power. The laser has threshold for mode - locked regime near 7 W for synchronous mode locking and 5 W for active mode locking.

We have analysed the laser system with Kerr lens feedback in the phase trajectory of five-dimensional space. We report the results of computer simulations of chaotic instabilities in mode-locked regime in tunable Cr^{4+}:YAG laser. The computer simulations have shown the presence of asymptotically stable stationary point in behaviour of temporal Gaussian beam similar spatial mode structure in the resonators, when the temporal mode does not change passing through all dispersion element in laser. We investigate parameters of resonators for obtaining stable and unstable Kerr lens mode locking. Our calculations show that the sign of dispersion is very important for formation of phase portrait in our laser system. The theoretical investigation of stability mode-locked in laser bring out the criterion of stable operation of laser in Kerr mode-locking. The analysis of the solutions in our model reveals that chaotic instabilities can be reached through increasing of non-linear interaction temporal and spatial Gaussian beam.

WO33

Waves in a nonlinear three-layer structure

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We consider propagation of TE-polarized waves

$$\vec{E} = \vec{e}_y E(n, z, \omega_0) e^{i(nk_0 x - \omega_0 t)}$$

in a lossless isotropic structure with three nonlinear layers (homogeneous perpendicular to the z-direction) and the permittivity

$$\epsilon_\nu = \bar{\epsilon}_\nu + a_\nu |\vec{E}|^2, \quad \nu = c\,(z > d),\ f\,(0 < z < d),\ s\,(z < 0).$$

Here, $\vec{E}$ is the electric field in the layers; $\vec{e}_y$, the unit vector of the axis Oy; nk_0, the effective wavenumber; $k_0 = \omega_0\sqrt{\mu_0\epsilon_0}$, the wavenumber of free space; ω_0, the fixed angular wave frequency; and $\bar{\epsilon}_\nu$ and a_ν are real constants. The field intensity E^2 in the three nonlinear media is expressed in terms of Weierstrass' function $\wp$. Though singular solutions were found, conditions for existence of real, nonnegative and bounded (CRNB) field intensities E^2 and of solutions to the corresponding dispersion relations (DRs) were not presented.

We use the properties of $\wp$ and find E^2 obeying CRNB that satisfy the boundary conditions at the interfaces $z = 0, d$ (that produce the DR) and at infinity $|z| \to \infty$. To be "physical" the field intensities must obey CRNB and DR, and $E^2(z)$ must be twice continuously differentiable in each layer and continuously differentiable on the line. Subject to CRNB and DR, we obtain conditions for real tupels $\{a_\nu, \bar{\epsilon}_\nu, n, E^2(n, 0, \omega_0), k_0 d\}$, $\nu = s, f, c$, associated with physical solutions E^2 and elaborate the technique to solve the problem practically: If $k_0 d$, a_ν, $\bar{\epsilon}_\nu$, $\nu = s, f, c$ are given fixed, we verify analytically and numerically whether certain domains in the (E_0^2, n)-plane exist, where CRNB are satisfied. Several numerical examples are presented.

WO34

THEORY OF NON-LINEAR EFFECTS IN LASER DIODE ARRAY: SLOWLY VARYING ENVELOPE APPROXIMATION

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Semiconductor laser arrays with active region located at lower refraction index show a great promise as a high-power coherent radiation source producing laser beams with diffraction limited quality [1]. In resonant arrays, where as in an element as in interelemental region the half-integer number of lateral waves are fit, coupling between elements is strong resulting in stable phase-locking. That's why the theoretical description of laser arrays is of interest

Coupling between active elements is strong because in the resonant array there exists a wave propagating in lateral direction almost not experiencing any reflection. This fact allows us to introduce in the Helmholtz equation an approximation of a slowly varying envelope (SVE). Paper presents derivation of an equation for the SVE from Helmholtz equation based on a method of 2x2 translation matrices. The SVE depends on a position of an element center in the periodical array. The equation derived is of the second order in derivatives over space and time, and in particular cases can be reduced to either hyperbolic or parabolic types.

On the ground of the equation derived, conditions for the self-focusing of a laser beam with a planar wavefront are expressed explicitly. It is found that self-focusing can realise in dependence on a sign of deviation of array parameters from exact resonance. Even if basic semiconductor nonlinearity is of the self-focusing type, the beam propagation may be stable. The maximum instability increment and the most dangerous disturbance wavelength are found explicitly. In the paper, soliton-type solutions to the derived equation will be presented too.

[1] D. Botez in *Diode Laser Arrays* ed. by D. Botez and D. R. Scifres, Cambridge Univesity Press 1994, pp. 1-71.

THE GAS LENSES AS THE NONLINEAR OPTICS ELEMENTS FOR THE LASER COSMIC ENERGY SYSTEMS

WO35

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A global cosmic systems may be used for Earth energy problems solutions in the nearest future. Such systems can involve several cosmic platforms on the polar or the heliostationary orbits. The present paper deals with prospects for using the various gas lenses for the cosmic power systems. The parameters studies are conducted for a such laser energy system conception. A laser system general scheme consist of a high power laser with the optics elements on a cosmic orbit and receiver - converter on Earth. The various types of the high power lasers with solar energy pumping can be used in a such system : a laser with pumping of a "black body" radiation [1], a laser with R.F. excitation, a gas-dynamic laser et.A high power laser beam is at the output window of any type laser. An exit laser beam can be a Gauss type , a Bessel type or other. The various optics elements are used in the such systems [2]: concentrators, collectors, mirrors, gas lenses, laser beam transformer axicons, laser beam expanders et. The necessary collector size for laser under solar energy pumping with a power W = 10 MW, is 750 x 750 m^2, for example. The surfaces of the optics elements can be made from the thin films. In this case the such optics elements dimensions is not too large for the laser cosmic systems and can be made in our time already. A reflection coefficient dependence of the inert gases from pressure is used in the gas lenses. The gas lenses are the nonlinear optics elements. The gas lenses without any covers can be used for the impulse laser beams. In this case a Joule - Tompson law must be take into account. For the constant laser beams the lens covers can be coated with long-lasting polymeric and no fragile materials. The warranty period for flexible covers with modern materials is up 3 years. The gas lenses can be a good concurrent for thin films mirrors in some cases which are in a consideration.

This work had been supported by Russian Foundation of Basic Research under Grant No. 96-02-18776.

REFERENCES

1. Klimovskii I.I., Kuzyakov B.A. Laser with a solar emission pumping. Patent Russia No. 2 098 980, Invention Bulletin, No. 25, 1997.
2. Klimovskii I.I., Konev Y.B., Kuzyakov B.A. An effective power supply of the Earth subjects with the space lasers under a solar energy excitation. International conference "An impact to matter of the high energy beams ". Terscol, 1997, pp. 54-55.

THURSDAY

2 July 1998

SESSIONS:

ThA - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics III
ThB - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures III
ThC - High-Precision Measurements in Optics III
ThD - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine III
ThE - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics III
ThF - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics IV
ThG - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures IV
ThH - High-Precision Measurements in Optics IV
ThI - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine IV
ThJ - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics IV
ThK - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies I
ThL - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures V
ThM - Interference Phenomena in Atomic Systems I

SESSIONS:

ThN - Postdeadline Papers I
ThO - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics V
ThP - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies II
ThQ - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures VI
ThR- Interference Phenomena in Atomic Systems II
ThS - Postdeadline Papers II
ThT - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics VI
Poster Session
ThU - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies
ThV - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures
ThW - Interference Phenomena in Atomic Systems
ThX - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine
ThY - Biomedical Optics
ThZ - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics

13 Зак. 208

8:30-10:30 **GREEN HALL**

ThA - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics III

Presider: *A.Z. Grasiyuk, Lebedev Physics Inst., Russia*

8:30
ThA1
(Invited)

FOUR-PHOTON POLARIZATION SPECTROSCOPY OF LIQUID WATER AND AQUEOUS SOLUTIONS

A.F.Bunkin, G.A.Lyakhov

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The experimental and theoretical results on water and aqueous solutions four-photon spectroscopy are presented. The measurements are carried out in the bands 0 - 3 cm^{-1}, 5 - 10 cm^{-1}, 15 - 100 cm^{-1} and 3000 - 4000 cm^{-1}. An interference of Kerr, Rayleigh, and Brillouin nonlinearities, which deforms specifically the detected spectrum have been found in the band 0 -3 cm^{-1}. This fact allows mutual calibration of cubic nonlinearities related to above mentioned processes.

For the first time by optical method, the resonance caused by hydrogen bond proton tunneling is detected in the region 6 cm^{-1}. In the spectral band 15 - 100 cm^{-1} the four-photon spectra of intermolecular and collective vibrations of water molecules with the frequencies 15, 29, 39, 47, 51, 58, 65, 80 and 84 cm^{-1} are predicted theoretically and observed experimentally.

In the band 3000 - 4000 cm^{-1} the structure of inhomogeneously broadened stretching vibrations Raman band have been resolved and the spectroscopic parameters of various lines inside the Raman contour have been measured. Temperature anomalies of the spectral parameters near to phase transition points 4, 18, 36 and 75^0 C are detected.

Changes in the geometric structure of molecular complexes in acetone and KCl aqueous solutions caused by variations in temperature and impurity concentration are detected. The detected spectral deformations may be attributed to strengthening the quasicrystalline net of hydrogen bonds and to partially suppressing certain orientational motions of water molecules in solutions. In the aqueous solutions of azine compounds one can measure the parameters of structural anomaly of dissolubility, caused by O...H and H...N hydrogen bonds creation interference.

9:00
ThA2
(Invited)

Methods of high resolution laser spectroscopy of helium

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High resolution laser spectroscopy of the hydrogen atom permits confrontations between experiment and fundamental physical theories. The next quantum-mechanical system (in complexity) after the hydrogen one is a helium atom. In spite of the fact that the calculation problem of energy levels of helium with high accuracy is rather complicated, a lot of carried out work shows, that the achievement of accuracy 0.1 MHz is quite real (see, for example, [1]). It means, that for helium a problem, analogical to the hydrogen one, can be put and solved: comparison of the theory and experiment. Such comparison is important for theory, first of all for quantum electrodynamics, as we are dealing with such a nontrivial problem as Dirac equation for two electrons in an external field of a nucleus. The precondition is the fact, that up to now with the help of methods of high resolution laser spectroscopy absolute measurements of frequencies in an optical range with relative accuracy 10^{-10}-10^{-14} are carried out.

In this work we will with the metastable 2^1S and 2^3S levels of helium and an opportunity of measurement of the 2^1S-2^3S transition frequency. We have analyzed the basic methods of high resolution laser spectroscopy for this transition - the method of saturated absorption (λ=1.56 mkm) and the method of two-photon absorption (λ=3.11 mkm) [2]. The conducted analysis assumes the direct use of the saturated and two-photon absorption methods and shows difficulties of their use. It is necessary to have rather powerful and stable lasers. Nevertheless we hope, that the experimental realizations can be essentially improved using various updatings of these methods.

In [3] theoretically and experimentally it is shown that a resonance with homogeneous width of the forbidden transition can arise on the line shape of the stimulated Raman scattering. We consider this resonance in helium, when the pumping is a running wave (corresponding to the 2^3S-2^3P_1 transition, λ=1083 нм) and the stimulated scattering is a standing wave (the 2^3P_1-2^1S transition, λ=3561 нм). Intensity of the resonance with homogeneous width (order 100 kHz) of the forbidden 2^1S-2^3S transition is found.

Our results permit us to make a conclusion that the low-lying energy levels of helium can be measured with accuracy 0.1 KHz. We hope that the results presented in this work will stimulate experiments on measurements of frequencies of helium transitions up to this accuracy.

1. G.V.Drake, I.B.Khriplovich, A.I.Milstein, and A.S.Yelkhovsky. Phys.Rev. **A 48**, R15 (1976).
2. V.C.Letokhov, V.P.Chebotaev. *Ultrahigh-Resolution Nonlinear Laser Spectroscopy*. Moscow, Nauka, 1990.
3. E.V.Baklanov, I.M.Beterov, V.P.Chebotayev, and B.Y.Dubetsky. Appl.Phys. **11**, 75 (1976).

9:30
ThA3
(Invited)

LOW FREQUENCY LASER DYNAMICS AND NEW PRINCIPLES OF LASER SPECTROSCOPY

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It is well known that the steady-state regime in lasers with slow relaxing active medium is set in an oscillatory way. Relaxation oscillations form a set of low frequency eigenoscillations, which mainly belong to antiphase dynamics, in addition to a set of optical modes [1]. The correspondence between the two sets of laser eigenoscillations opens up new opportunities for using lasers in both basic and applied physical researches. This statement is illustrated in the present talk at the example of intracavity laser spectroscopy.

We discuss the possibility to acquire information on subtle features of the emission spectrum of a cw multimode laser by studying power spectra of individual modes and modulation transfer functions. In the simplest case, the number of lasing modes is equal to the number of relaxation oscillations. The latters are exhibited as resonances in the power spectra of individual modes and in transfer functions the exact form of which depends on structure details of field spectrum. In particular, the transfer functions which characterize the laser response to a weak periodical pump modulation, are sensitive to nonuniformity of loss and gain distribution along the set of cavity modes. This result has been obtained by numerical computation of eigenvectors and transfer functions in case of symmetrically arranged field spectrum as well as in various kinds of symmetry breaking.

The presented consideration theoretically substantiates the principle possibility to perform absorption measurements using methods which are non-conventional for intracavity laser spectroscopy. Sensitivity of relaxation oscillations to the values of various control parameters is a very promising point for solution of other inverse problems of laser dynamics.

The work was supported by RFBR grants #96-02-19274 and # 96-15-96742.

1. Ya.I .Khanin, Chaos, v.6 p.373, 1996

10:00
ThA4
(Invited)

LAST RESULTS OF CRYSTAL DOPE CENTRES INVESTIGATION BY THE POLARISATION ANISOTROPY OF NONLINEAR ABSORPTION METHOD

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Two groups of questions are discussed in this report: a) non-linear optical anisotropy of cubic dope crystals, and b) connection of this anisotropy with energy and polarisation state of output radiation of neodymium lasers passively Q-switched by $LiF:F_2^-$, $YAG:Cr^{4+}$ - crystals. The polarisation anisotropy of non-linear absorption method is based on the dependence of powerful light absorption on polarisation state of the light. Both this method and the well-known polarised luminescence method are based on the fact that dope atom (or vacancy) can occupy only definite positions in the crystal under investigation. In some cases it is possible to find out the kind and direction of absorption transition of a given dope centre in crystal by this method. One of the first mention of a possibility to detect the dependence at high light intensity was made in [1]. We have studied by this method $LiF:F_2^-$, $YAG:Cr^{4+}$, and $YAG:V^{3+}$ crystals at wavelength 1.06 μm and find out that linear dipole transitions F_2^- colour centre in LiF are directed along six [110], [-110] type axes. In the later two crystals linear dipole transitions are directed along principal crystallographic axes. For $YAG:Cr^{4+}$ this affirmation was stated in [2]. Change of state polarisation of the powerful light propagating through the crystals has been investigated experimentally and results are presented.

$LiF:F_2^-$ and $YAG:Cr^{4+}$ crystals are commonly employed as passive Q-switches of neodymium lasers. Results of investigation of bleaching of F_2^- - colour centres in LiF under powerful radiation with wavelength 1.06 μm are presented. State of polarisation of output radiation of neodymium laser with $YAG:Cr^{4+}$ Q-switch has been investigated and results are discussed. 1. M.I.Dykmann, G.G.Tarasov. *Zh. Eksp. Teor. Fiz.*, **72**, 2246(1977). (*Sov. Phys. JETP*, **45**, 1181(1977)). 2. H.Eilers, K.R.Hoffman, W.M.Dennis, S.M.Jacobsen, W.M.Yen. *Appl. Phys. Lett.*, **61**, 2958(1992).

8:30-10:30 **RED HALL**

ThB - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures III

Presider: *F. Traeger, Univ. Of Kassel, Germany*

8:30
ThB1
(Invited)

Paper is not available

9:00
ThB2
(Invited)

New nonlinear optical crystals for laser physics and its applications

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Under nano-, pico- and femtosecond laser pulses propagation through different types of insulating crystals having considerable high $\chi^{(3)}$ ($KY(WO_4)_2$ (space group C_{2h}^6), $KGd(WO_4)_2$ (C_{2h}^6), $KLu(WO_4)_2$ (C_{2h}^6), $KY(MoO_4)_2$ (D_{2h}^{14}), $LiNbGeO_5$ (D_{2h}^{16}), $Ca(NbO_3)_2$ (D_{2h}^{14}), $PbWO_4$ (C_{2h}^6), $CdWO_4$ (C_{2h}^4), and $Ca_3Ga_2Ge_3O_{12}$ (O_h^{10}) with ordered structure, and $NaLa(MoO_4)_2$ (C_{4h}^6), $NaBi(WO_4)_2$ (C_{4h}^6), $NaY(WO_4)_2$ (C_{4h}^6), and $Ca_3Ga_2Ge_4O_{14}$ (D_3^2) with disordered structure), as well as simultaneously $\chi^{(2)}$ and $\chi^{(3)}$ ($LaBGeO_5$ (C_3^2), β'-$Gd_2(MoO_4)_3$ (C_{2v}^8), $Ca_4Gd(BO_3)_3O$ (C_s^3), and $NaClO_3$ (T^4)) nonlinearities were discovered and investigated several new manifestations of optical nonlinear interactions. Among them are:

- efficient multiple anti-Stokes (up to 15-th order in $LiNbGeO_5$, $NaLa(MoO_4)_2$), $PbWO_4$, etc.) and Stokes generation by collinear cascade stimulated Raman scattering (SRS);
- second-harmonic SRS-excitation and Stokes and anti-Stokes generation in $\chi^{(2)}+\chi^{(3)}$ crystals by both the fundamental and arisen in them SHG ($LaBGeO_5$, β'-$Gd_2(MoO_4)_3$, and $Ca_4Gd(BO_3)_3O$), etc.

In this report I would like to discuss also several new possible applications of discovered nonlinear optical potentialities for creation of novel generation shemes of rare-earth crystalline lasers, in particular, new self-frequency doubled and self-SRS lasers, etc. I will discuss here quite recently observed high-order SRS in several laser garnets (including $Y_3Al_5O_{12}$), α-Al_2O_3, as well as in ultra-low-energy phonon $PbCl_2$ crystal.

9:30
ThB3
(Invited)

NONLINEARITY OF LIQUEFYING GALLIUM: A BREAKTHROUGH OPPORTUNITY FOR CONTROLLING LIGHT WITH LIGHT AT MILLIWATT POWER LEVELS

S. Dhanjal+, V.I. Emelianov**, P. Petropoulos*, D.J. Richardson* and N.I. Zheludev+

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We have found that an interface between glass and metallic gallium held just below the melting point shows an astonishingly large broadband cubic nonlinearity reaching {chi}(3) ~ 1esu . his constitutes a new type of nonlinear optical response. This large nonlinearity is available in a very versatile material geometry, it works at room temperature and has major device potential in optoelectronics. The physical mechanism behind the nonlinearity is related to a new type of optically induced phase transition between two phases of gallium and shows critical behavior of the material susceptibilities and relaxation times appropriate to a second-order phase transition. The nonlinearity is much faster than in liquid crystals and has the advantage of being very broadband in comparison with the near band-gap and exitonic nonlinearities in semiconductors. It spans from visible to near infrared covering important telecom spectral windows. The nonlinearity is fully reversible and the effect is stable as long as the sample temperature is maintained to within 1°C just below the melting point of gallium which is about 29°C We have demonstrated that the nonlinearity is fully compatible with waveguide technology as the gallium mirror may be formed at the tip of a single mode fiber. A high-contrast optical switch has already been demonstrated operating at milliwatt light power levels, with a roll-off frequency in excess of 100kHz. The switch is also capable of routing sub-microsecond optical pulses. In another application, a liquefying gallium mirror was used to achieve q-switching of an erbium fiber laser.

1. N.I.Zheludev, D.Richardson, S.Dhanjal. UK Patent application # 9724150.9 of 14th of November 1997.
2. P.J.Bennett, S.Dhanjal, P.Petropoulos*, D.J. Richardson and N.I.Zheludev Nonlinearity Of Liquefying Gallium: Controlling Light with Light at Milliwatt Power Levels. IQEC?98 San Francisco, CA, USA, May 1998. Paper QME7.
3. P. Petropoulos, D.J. Richardson S. Dhanjal and N.I. Zheludev. Passive Q-switching of an Erbium Fibre Laser Using Nonlinear Reflection from a Liquefying Gallium Mirror. CLEO?98 San Francisco, CA, USA, May 1998. Peper CTuE5.

10:00
ThB4

Pulse Compression in Photonic Crystals

N.I. Koroteev, S.A. Magnitskii, A.V. Tarasishin, and A.M. Zheltikov

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Photonic bad-gap (PBG) structures [1] have been widely investigated in recent years in connection with a broad variety of applications, including the control of spontaneous emission [1], vertical-cavity surface-emitting semiconductor lasers [2], Bragg-reflecting structures [3], low-threshold optical switching [4], etc. At the same time, as highlighted in [5], PBG structures also provide an opportunity to control the group and phase velocity of light pulses whose frequencies lie near the edge of the relevant band gap.

In this paper, we consider the possibilities of pulse compression in photonic crystals. Based on the estimates for one-dimensional PBG structures and numerical simulations for photonic crystals whose parameters are close to those implemented experimentally, we will demonstrate that photonic crystals allow chirp compensation and pulse compression on a submillimeter spatial scale (Fig. 1), which permits us to propose a concept of Compact Pulse Compressors based on Photonic Band Gaps (ComPBag), providing new opportunities for the miniaturization of femtosecond solid-state laser systems.

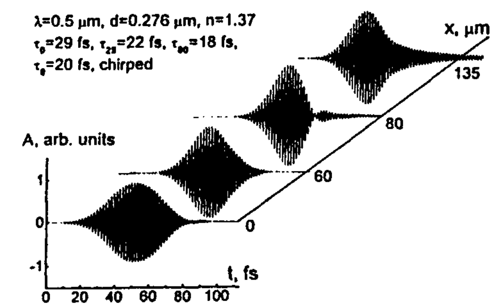

Fig. 1. Compression of a chirped laser pulse in a one-dimensional photonic crystal.

This work was partially supported by the Constellation Group GmbH (Austria).

References

1. Yablonovitch E., *Phys. Rev. Lett.*, 1987, **58**, 2059; John S., *Phys. Rev. Lett.*, 1987, **58**, 2486; *Photonic Band Gaps and Localization*, Soukoulis C.M., Ed. (Plenum, New York, 1993).
2. Yokoyama H., Nishi K., Anan T., Yamada H., Brorson S.D., and Ippen E.P., *Appl. Phys. Lett.*, 1990, **57**, 2814.
3. Baba T., Hamano T., Koyama F., and Iga K., *IEEE J. Quantum Electron.*, 1991, **27**, 1347.
4. Radis S., George N., and Agrawal G.P., *J. Opt. Soc. Am. B*, 1995, **12**, 671.
5. Dowling J.P., and Bowden C.M., *J. Mod. Opt.*, 1994, **41**, 345.

10:15
ThB5

Photophysics in highly ordered polyacetylene: high Raman scattering and long-lived electron-deformational states

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*Institute of Chemical Physics, Moscow 117977, Russia

Polyacetylene, $(CH)_x$, is the chemically simplest π-conjugated polymer that is a non-luminescent quasi-1D semiconductor with the optical gap $E_g \sim 1.7$ eV. The initial photoexcitation of the *trans*-$(CH)_x$ chain relaxes with high probability into the coupled electron-lattice state. It has been established that these states are long-lived (~ 0.1 ms) and neutral. They are observed as a photoinduced absorption band below the fundumental absorption edge of *trans*-$(CH)_x$.

We present the results of studies by a number of optical methods (Raman, cw/picosecond photoinduced, photoexcitation, and electroabsorption spectroscopies) on recently synthesized highly ordered and stable form of $(CH)_x$. This form of $(CH)_x$ comprises of ~ 10 nm particles dispersed in a matrix of polyvinilbuteral. The $(CH)_x$ nanoparticles have a sharp absorption spectrum with well-resolved vibronic structure and rather narrow lines of the Raman scattering spectrum. This indicates a narrow distribution of nanoparticles in size and their highly ordered crystalline structure. Our highly ordered form of $(CH)_x$ has a long-term stability no less than 5 years and reveals no symptoms of photooxidation.

Our results demonstrate two groups of unique optical properties (important for applications) that originate from the fact that the dynamics of π electrons and the lattice in *trans*-$(CH)_x$ are strongly bound together. The first group concerns the Raman scattering effects: first of all, we have observed an unprecedentedly high Raman scattering cross-section in the transparency range of $(CH)_x$. Our Raman studies seem to indicate an unknown type of resonance which is not connected with the resonant $1A_g$-$1B_u$ electronic transition. We suppose that the observed Raman effects are associated with dipole-forbidden A_g-states located within the optical gap of *trans*-$(CH)_x$.

The second group of our results relates to the long-lived neutral states: we have found that the efficiency of their photoexcitation increases dramatically with the energy of an exciting photon. The most efficient photoexcitation of the neutral gap states per absorbed photon occurs in the 'blue' spectral range where the $(CH)_x$ film is nearly transparent. Concerning the microscopic mechanism of this effect, we suggest that the excess photon energy $(\hbar\omega - E_g)$ contributes to the vibrational subsystem of *trans*-$(CH)_x$ ibcreasing the probability of relaxation of the π-conjugated chain in a deformed neutral long-lived state. The time of formation of the neutral long-lived photoexcitations is expected to be on the sub-picosecond time scale. These properties of *trans*-$(CH)_x$ can be used for optical data processing and dynamic data storage.

8:30-10:30 **BEIGE HALL**
ThC - High-Precision Measurements in Optics III
Presider: *T.Haensch, Max-Planck-Institute of Quantum Optics, Germany*

8:30
ThC1
(Invited)

Large Quantum limits in the ultimate resolution of optical instruments.

C Fabre, A. Maitre, M. Vaupel

With the tremendous development of video signals, the subject of image formation, acquisition and processing is at the center of many investigations in optics.\ For fundamental reasons, as well as for applied purposes, it is important to kow precisely in which respect the quantum nature of light influences the determination of optical images, and in particular to ascertain whether the unavoidable quantum fluctuations in light impose a limit to the quality of such measurements.\ Within the last few years, an increasing number of papers has been devoted to the quantum aspects of the transverse structures produced or processed by various optical devices (1,2,3), in particular with the concept of "quantum images"(4). The light field in a given transverse plane is characterized by its value measured at each pixel position, and the statistical properties of the light are characterized by the covariance matrix of intensity correlation functions. If the field is in a quasiclassical state, the cross-correlation functions at two different pixels are zero, and the autocorrelation function at a given pixel gives rise to a "local" shot noise. Multimode nonclassical states of light will then be characterized by eithernonclassical correlations between different pixels, or by a local squeezing behaviour, or by both. We will give different examples of multimode nonlinear optical devices likely to produce such light beams. We will then consider the two-pixel problem, in which a split-photodetector separately measures the light intensity in the two-half parts of the transverse plane. Such a configuration is widely used in high sensitivity position measurements, for example in biology. One can show that in such a problem, the standard quantum limit in the resolution of the position measurement is simply the diffraction limit divided by the square root of the number of photons used in the measurement. This limit can be overcome by using different kinds of nonclassical fields, for example, light beams where the light fluctuations are perfectly quantum correlated at any two points symmetrical with respect to the beam center.We will finally show that this kind of light beam can be generated by a highly transverse multimode Optical Parametric Oscillator, and give preliminary results about the experimenta setup that we are currently developing in order to implement such a theoretical scheme.

(1) M.\ Kolobov, A.\ Sokolov, Phys.\ Letters **A140**, 101 (1989)
(2) M.\ Kolobov, P.\ Kumar, Optics Letters **18**, 849 (1993)
(3) M.\ Kolobov, L.\ Lugiato Phys Rev **A52**, 4930 (1995)
(4) I.\ Marzoli, A.\ Gatti, L.\ Lugiato, Phys Rev Letters **78**, 2097 (1997)

9:00
ThC2
(Invited)

Generation of nonclassical polarization states and measurement procedure in quantum optics

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SUMMARY

In our paper the generation of quantum polarization states of light with nonclassical phase behavior we consider for the first time. To discribe in general such a quantum field we introduce two pairs of the phase operators being namely the two phase angles φ and ψ for the Hermitian polarization Stokes parameters of light S_j (j=0,1,2,3) in 3D-picture of the Poincare sphere. The presence of fluctuations of both phases and amplitudes for polarized modes results in some uncertainty in the Stokes parameters of light S_j and in the angles φ and ψ. To measure simultaneously the all Stokes parameters we propose an eight-port (four channel) interferometer resulting in observation of each Stokes parameter but in accordance with the corresponding uncertainty product. The quantum operational approach allows to carry out the simultaneous measurements of optical phases (i.e. the phase angles φ and ψ) for two polarized modes as well. Using an anisotropic Kerr-like nonlinear medium associated with the polarization interferometer we can generate and also observe a new quantum state of light, i.e. the polarization-squeezed phase state of light. The fluctuations of the phase difference between two orthogonally polarized modes for such a nonclassical state are less than the fluctuations for light in coherent state. Discussed above set-up could be also used to measure of the light polarization degree in quantum optics.

9:30
ThC3
(Invited)

INVESTIGATION OF THE OPTICAL ISOTROPY OF SPACE

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Precision laboratory experiments for determination of space isotropy via orientation dependence of light velocity are described. It had been established that the velocity in rarefied and condensed media does not depend on derection of light propagation with relative accuracy not worse than 5.10^{-8}

10:00
ThC4

Low-coherent interferometry with passive ring resonators

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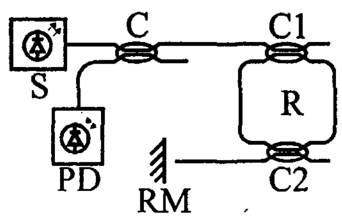
New method for phase nonreciprocity detection in a high-finesse passive ring resonator is discussed in which low-coherent light source is used. Different variants of low-coherent ring resonant interferometers (LCRRI) are considered. The main idea of low-coherent ring-resonance interferometry is illustrated by Figure which is represents the simplest geometry of LCRRI. Light from source *S* passes through the ring resonator *R* (which is formed by fiber loop with two couplers *C1*, *C2*) in clockwise (cw) direction (from source to retro-reflecting mirror *RM*), leaves the resonator, returns to resonator after reflection from retro-reflecting mirror *RM*, passes through resonator in counter-clockwise (ccw) direction, and, finally, reaches the photodetector *PD* by 50% coupler *C*. The spectrum of light coming to retro-reflecting mirror is the series of narrow peaks at cw resonant frequencies. Ccw transmission spectrum has the same shape but its peaks are at ccw resonant frequencies. Hence, output light intensity P_{out} depends on the nonreciprocal bias between cw and ccw resonances:



$$P_{out}(\Delta\varphi) \propto F^{-1}(1+(F/\pi)^2 \sin^2(\Delta\varphi/2))^{-1}$$

where $\Delta\varphi$ is phase nonreciprocity in resonator per roundtrip, F is the finesse of resonator.

Modulation/compensation of phase nonreciprocity can be performed by frequency shifter arranged between resonator and retroreflecting mirror. The main advantages compared with conventional methods of passive ring resonant interferometry with high-coherent light sources are (i) reduced backscattering noises, (ii) insensitivity to resonant frequencies drift caused by reciprocal effects (e.g. thermal expansion of resonator). The feasibility of proposed method is confirmed by experimental observation of Sagnac effect in low-coherent ring resonant interferometer.

10:15
ThC5

LASER NANOINTERFEROMETRY OF DISPLACEMENTS: METHODS AND MEANS OF MEASUREMENT ACCURACY IMPROVEMENTS

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The application of laser-interferometric transducers of subnanometre resolution [1] in control systems of high precision coordinate device displacements allows its position in practically any point of set up working field or give the speed of movement in the wide range (no less than 80 dB) [2]. It allows to synthesize the photomask topology of different complex form.

The important problem is to receive the high precision of topology forming. The classical problems in systems using laser-interferometric transducers resulting, for example, under *the change of environment conditions (air) were discussed more than once [3].* The situation becomes more complex when the transducers with high resolution are used in devices with inner heat sources. For example, in laser photoplotter of submicron resolution CLWS-300 [4] working in polar coordinate system these inner heat sources are the following: powerful Ar laser in writing channel, driver of spindle rotation in angular coordinate, laser and linear driver in R-coordinate. Their operation results in appearance of non-stationary temperature fields, which leads to dreif of some device parameters *(for example, the shift of spindle rotation center). As a result of this the distortion* of synthesized element topology happens. The temperature field stabilization is reached after 6 - 8 hours of continuous work of all device units. It is clearly that we are to take into account the influence of these sources on the topology forming precision.

The basic methods and technical means which are used to increase the accuracy of element topology forming are analyzed. These methods are the following: development the differential interferometer of special construction, transmission of analog signals on *fiber optics, automated measurement of absolute value of laser radiation wavelength and* so on. The possibility of new perspective measurement method application: method of two-wave interferometry of displacement is estimated.

REFERENCES

1. Hosoe S. Laser interferometric system for displacement measurement with high precision. «Nanotechnology», 2, (1991), 88 -95.
2. Kiryanov V.P. «Method of direct reconstruction of quadrature signal phase and its *application in positioning systems with nanometric resolution».* «Avtometriya», № 3, 1997, p. 109.
3. Steinmetz C.R. Sub - micron position measurement and control on precision tools with laser interferometers. «Precision Engineering»,12, № 26 (1990), 12 -24.
4. Kiryanov V.P. Laser Setup for Flat Optical Components with Submicron Resolution. - Proc. SPIE, 1997, **3091**, p. 66 - 70.

8:30-10:30 **PRESIDENT'S HALL**

ThD-Basic Concepts of Laser Chemistry, Biophysics and Biomedicine III

Presider: *O.M. Sarkisov, Semenov Inst. Of Chemical Physics, Russia*

8:30
ThD1
(Invited)

PRECISION LIGHT SCATTERING SPECTROSCOPY FOR STUDY DETERMINATE MOVEMENT OF BIOLOGICAL OBJECTS

Sergey N. Bagayev[a], Victor A. Gusev[b], Valery A. Orlov[a], Sergey V. Panov[a]

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A search for the laws of the ordering movement of macromolecular structures responding to safety and self-reproduction of any living system is a fundamental problem. A self-reproduction of living cell as a manifestation of the processes of a self-organization is determined by its capability for searching of "building stuff" and energy source in the surrounding environment. The motility of the microorganisms, in particular, is an external manifestation of the internal self-organized movements of the macromolecular formations, building blocks of living cell. The emergence of the technique for the visualization of the cooperative movement of the macromolecules involved in the chemical reactions would allow to answer the one of the main questions of the living system Physics. By what way is self-organization in the bio-systems i.e., a transition from the Brownian movement of macromolecules to the determined movement?

To discriminate determine movements inside living systems it is necessary to use adequate technique. Well-established high-sensitive techniques of laser absorption spectroscopy, fluorescence spectroscopy and Raman spectroscopy allow to study the intramolecular processes because they are based on the registration of the high frequency spectra of the electronic, oscillating and rotational transitions. Whereas fermentative biochemical acts are related to the cooperative movement of the macromolecular complexes. Movements of this kind are realized in low frequency domain and are accessible to study by high-resolution light scattering spectroscopy.

The work based on the original experimental results covers the questions relating to cooperative movements of macromolecular biological complexes, peculiarities of microorganism motility, physiological role of water and water solutions in dynamics of biological processes.

9:00
ThD2
(Invited)

Paper is not available

9:30
ThD3

CIRCULAR ELECTRODICHROISM IN CHIRAL LIQUIDS

N.N. Brandt[1], A.Yu. Chikishev[1], N.I. Koroteev[1], S.P. Palto[2]

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The applications of nonlinear optics in the studies of chiral media are extensively developed in recent years. It was demonstrated earlier that these are only even nonlinear susceptibilities that are chiral-specific. The spectral dependences of the components of the tensor of dielectric susceptibility provide novel information on the structure of the chiral molecules.

We present the results of theoretical consideration of the interaction of quasistatic electric field with the electric field of the light wave in the chiral media. We demonstrate the existence of the wavelength-dependent modulation of light passing through the chiral media at the fundamental and second harmonics of the quasistatic electric field. The intensities of modulated signal components at fundamental modulation frequency Ω and it's second harmonic are proportional to the imaginary parts of the second and third order nonlinear optical susceptibilities, respectively:

$$I(\Omega) \approx 4I\pi \frac{\omega n''}{c|n^2|} U_0 \operatorname{Im} \chi^{(2)}(\omega), \qquad I(2\Omega) \approx 4I\pi \frac{\omega}{cz} U_0^2 \operatorname{Im} \frac{\chi^{(3)}_{1122}(\omega)}{n}$$

where I is the integral intensity of light passing through the chiral medium, ω is the optical frequency, c is the speed of light, n is the complex refractive index, n'' is the imaginary part of the refractive index, U_0 is the amplitude of the quasistatic electric voltage. The signal at the first harmonic is equal to zero in case the medium is not chiral.

We detected the signals at the first and second harmonics of the modulation electric field for the solution of azodye D*5. The observed spectral dependences are determined by Kerr effect and the effect of circular electrodichroism.

9:45
ThD4
(Invited)

Two Photon Processes in Molecules : Applications to Photonics and Biophotonics

Paras N. Prasad
Photonics Research Laboratory
State University of New York at Buffalo

Recent development has produced novel materials with significantly enhanced two-photon absorption cross-sections and highly efficient up-converted emission.This achievement has opened up doors for many new technological applications. This talk will present our rational approach to design molecules and bulk forms with enhanced two- photon properties. Then the various techniques including femtosecond laser pulses being utilized in our laboratory to study the dynamics of two photon processes will be discussed.Finally, some of the technological applications which we are pursuing at SUNY Buffalo will be presented . They include optical power limiting , up-conversion lasing, image up-conversion phase conjugation, .microfabrication and MEMS,three-dimensional optical data storage as well as medical applications such as two-photon photodynamic therapy . The talk will conclude with an 11 minute video presentation of applications of two-photon processes which includes a 3 dimensional optical data storage of different movie frames of a Bugs Bunny cartoon .

8:30-10:30 **BLUE HALL**

ThE - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics III

Presider: *M.V. Fedorov, General Physics Inst., Russia*

8:30
ThE1
(Invited)

IONIZATION AND FRAGMENTATION EXPERIMENTS ON ATOMS AND MOLECULES IN THE INTENSE FIELD OF A FEMTOSECOND TI-SAPPHIRE LASER PULSE

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During the interaction of atoms and molecules with the intense field of a femtosecond Ti-sapphire laser pulse, we observed electron trapping, non-sequential ionization (up to Xe6+), molecular enhanced ionization preceding Coulomb explosion and suppressed/enhanced tunnel ionization of molecules.

9:00
ThE2
(Invited)

ROTATION, VIBRATION , DISSOCIATION AND IONIZATION OF DIATOMIC MOLECULES AND THEIR IONS IN A STRONG LOW-FREQUENCY LASER FIELD

Vladimir P. Krainov, M.B. Smirnov,
Moscow Institute of Physics and Technology, Dolgoprudny
and M.E. Sukharev,
General Physics Institute, Russian Academy of Sciences, Moscow

We calculate the barrier-suppression fields for the classical ionization of an ion of the hydrogen molecule and the neutral molecule by an electric field. In the case of a molecular ion we examine different internuclear separations, using two lowest electron terms, and obtain correct limits for the well-known cases of small and large internuclear separations [1,2].

Franck-Condon factors are calculated for the ionization of hydrogen and deuterium molecules in intense low-frequency laser fields. It is shown that the laser field shifts the maximum of the Franck-Condon factors towards higher ion excitation energies. In the strong-field case, the vibrational levels of molecular ions disappear and a continuum distribution of Franck-Condon factors is observed as a function of the vibrational excitation energy. Our results reduce to well-known values in the limit of a weak laser field. Effective dipole laser-molecular ion interaction is derived analytically. This interaction produces dynamic chaos in the dissociation process of hydrogen and deuterium molecular ions [3,4].

Dissociation of hydrogen and deuterium molecular ions by strong low-frequency laser field is considered in the frame of quasi-static approximation. Classical motion of nuclei in the dissociation process is analyzed. Energy spectra of nuclei are calculated [5].

Simple analytical expressions are obtained for energy and angular spectra of ejected electrons at the ionization of hydrogen molecular ion by low-frequency laser radiation. They oscillate as a function of the internuclear separation [6].

Vibration, rotation and dissociation of H_2^+ and Cl_2^+ ions are considered in the frames of classical mechanics [7]. It was found that pulse length influences strongly these processes.

References

1. M.B. Smirnov, V.P. Krainov: Sov. Phys. JETP, 85, 447 (1997)
2. M.B. Smirnov, V.P. Krainov: Laser Physics, 7, 826 (1997)
3. M.E. Sukharev, V.P. Krainov: Sov. Phys. JETP, 83, 457 (1996)
4. M.E. Sukharev, V.P. Krainov: Laser Physics, 7, 323 (1997)
5. M.E. Sukharev, V.P. Krainov: Laser Physics, 7, 803 (1997)
6. M.B. Smirnov, V.P. Krainov: Physica Scripta (1998) in press
7. M.E. Sukharev, V.P. Krainov: J. Opt. Soc. Am. B (1998) in press

9:30
ThE3
(Invited)

Paper is not available

10:00
ThE4

RYDBERG WAVE PACKETS ON ELLIPTICAL ORBITS.

E.A. Shapiro[1], M. Kalinski[2] and J.H. Eberly[3].
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We consider 2D Rydberg hydrogen dressed in a circularly polarized electromagnetic field with the frequency of the principal resonance. In classical mechanics, such systems are usually described with the help of the theory of nonlinear resonances. Uniform semiclassical quantization of this theory allows us to predict the shape of the Floquet states in Rydberg hydrogen [1]. Thus we predict that the "dressed" states in this system are just the field-free states localized in some angle θ responsible for orbital motion.

In our numerical calculation, we start from the field-free initial state $\psi_0 = \sum_{l=14}^{19} \psi_{n=20,l}$ which is strongly localized near single Keplerian ellipse. We solve time-dependent Schrodinger equation with the dressing field slowly turning on up to the field strength $E=0.02/n_0^4$. One can observe that the "dressed" state is now a wave packet that travels along elliptical trajectory with the period of classical orbital motion.

Research supported by CRDF Grant RP 241, NSF Grant 93-04335, and RFBR Grant 96-02-17649 (ES).

[1] E.A. Shapiro, M. Kalinski, and J.H. Eberly, to be published.

10:15
ThE5

MULTIPHOTON PROCESSES IN MOLECULES WITH EXCITED VIBRATIONAL SQUEEZED STATES IN THE STRONG EM FIELD

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The preparation of squeezed vibrational states in molecules can be realized due to excitation by short intensive electromagnetic pulses or by means of hot photon impact.

The multiphoton processes in molecules with excited vibrational squeezed (or coherent) states are considered. The following problems are solved:

1) It is shown that participation of squeezed vibrations in multiquantum transitions leads to decreasing of the multiphoton process degree, the Landau-Zener effect type must be taken into account.

2) The High Harmonic Generation (HHG) by dipole molecules and local centers of crystals with excited vibrational squeezed states are considered. Generalization of cooperative Dicke model, with excitation by coherent EM field or super high frequency ultrasonic wave is given. The intensity of emitted harmonics is analyzed.

3) The light scattering processes due to vibrational squeezed states fluctuations are analyzed. It is shown that the amplitudes of the scattering processes increase abruptly with the growth of the squeezed state parameter. The theory of transient secondary emission spectra is constructed. The dependence of the time evolution of these spectra on the squeezed state parameters is established.

11:00-13:00 **GREEN HALL**

ThF - Novel Trends in Nonlinear Laser Spectroscopy and Optical Diagnostics IV

Presider *A.S. Provorov, Krasnoyarsk State Univ., Russia*

11:00
ThF1
(Invited)

DISCRETENESS AND LOCAL FIELD EFFECTS IN CLASSICAL MOLECULAR OPTICS

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Campus Universitario do Bacanga, 65080-040, Sao Luis,Ma, Brazil
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Semiconductor Physics Institute, RAS, Novosibirsk, Russia

The talk is devoted to the study of the connection of themacroscopic optical properties of the medium with its microstructure, i.e., geometric disposition of the elementary radiators and the distances b between them. First, steming from the supposition that certain new quantities constructed from the local field, polarization vector, electric-quadrupole and magnetic-dipole volume densities, and their gradients must satisfy both integral and wave equations, we apply well known in classical molecular optics the method of integral equations (MIE) for arbitrary nonlinear and anisotropic medium for three-dimentional (Phys.Rev.A,49, 1313 (1994)) and two-dimentional (Phys.Rev.A,50, 714 (1994)) cases. Only unitless geometric tensor of a lattice and the radiator's polarizability tensor, but not a lattice grain size b, determine the local field factor and enter into the anisotropic analogues of the Lorentz-Lotenz formula. A connection between the microscopic and macroscopic characteristics was established. Second, we generalized MIE (GMIE) to the case of a discrete weakly rarefied madium $b/\lambda<<1$, where λ is the light wavelength) (Phys.Rev.E,56, 6123 (1997)). Although just a discreteness gives rise to the local field effects "incorporated" into the Lorentz-Lorenz formula and anisotropic analogues, these formulas reveal only the presence of the medium's discreteness, but not its "magnitude" b. We pursue a line of thought by Mandelstam, who first demonstrated that effects of the effective amplification due to the propagation delay in the interaction of the radiators and the radiation damping effects for the regular isotropic mediumare exactly balanced against each other (Mandelstam cancellation). We prove this for any nonlinear and anisotropic regular medium. The general form of Extinction Theorem is found. The validity of Maxwell Equations is proved with the accuracy up to the third order of parameter b/λ. The developed approach enabled us to calculate the local fields factors and the dielectric permittivity of a rarefied medium. An essential quantitative and qualitative distinction between the gaslike, jellylike and cubic lattice media, customarily treated as optically isotropic, was revealed. Our results may be applied to calculation of the optical properties of some specific types of media, such as a cooled atomic gas, multicomponent composite materials, and quantum dot structures.

11:30
ThF2

NEAR-FIELD OPTICAL SECOND-HARMONIC MICROSCOPY

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Using an uncoated fiber tip as a light source, near-field images of a periodically poled $LiNbO_3$ crystal and of a multilayer Langmuir-Blodgett film of 2-docosylamino-5-nitropyridine (DCANP) are obtained at the fundamental and second harmonic (FH and SH) wavelengths while simultaneously recording surface topography. The experimental setup used consists of a stand-alone illumination scanning near-field optical microscope combined with a shear force based feedback system. The linearly polarized light beam from a mode-locked Ti-Sapphire laser (λ_ω = 750-860 nm, $P_\omega^{av} \approx$ 150 mW, repetition rate $f \approx$ 80 MHz, pulse duration $\tau \sim$ 200 fs) is coupled into a single-mode fiber terminated with a sharp etched tip. FH radiated from an uncoated fiber tip (and transmitted through a sample) and SH generated in a sample are collected by a microobjective and detected with a photodiode and a photomultiplier (connected with a photon counter), respectively. The tip can be scanned along the sample surface at a constant distance (~5 nm) by virtue of shear force feedback, thus resulting in a topographical image of the sample surface.

Domain walls in a periodically poled (z-cut) $LiNbO_3$ crystal are observed on near-field SH-images in the form of bright lines of ~400 nm in width for the SH polarization being perpendicular to the domain walls. Origin and selection rules for the contrast in SH-images of domain walls are discussed. Near-field SH-images of a DCANP film exhibited very bright submicrometer-sized spots with signal enhancement of up to 10 times. Their brightness is found dependent on the polarization of the pump indicating that the domains observed oriented differently but predominantly in the dipping direction. The spatial resolution of ~100 nm is achieved in near-field SH-images that are not correlated with both topographical and FH-images. Finally, it is found that the domains of different size exhibit different wavelength dependencies of the efficiency of SH generation, though their maxima are centered near the absorption peak of the SH wavelength corresponding to ~390 nm.

11:45
ThF3

Near-field Microscopy of Second-harmonic Generation

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Optical second-harmonic generation (SHG) is a sensitive technique for characterization and investigation of optical materials, surfaces and adsorbates. Like every optical technique, SHG has spatial resolution limited by Rayleigh criterion. Second-harmonic light observed in the far-field region is generated from relatively large area (typically not less than several μm^2) which is not uniform at microscopic scale. Combination of the second-harmonic generation and near-field optical microscopy (NFOM) opens a possibility for mapping of nonlinear optical properties with increased surface sensitivity provided by SHG and subwavelength resolution provided by NFOM.

In this talk, the experimental realization of near-field second-harmonic microscopy is reported. The spatial resolution of the microscope in the SH light collection mode has been determined to be better then 150 nm. The implementation of the technique to study second-harmonic generation from rough metal films, nonlinear crystals, ferroelectric and ferromagnetic materials will be discused.

Clear difference in the mechanisms of SH generation for different polarisations of excitation light has been demonstrated for rough metal surfaces. The dependence of the SH signal on tip-surface distance has also been examined verifying the presence of strong evanescent SH field components. We have demonstrated the imaging capability of the technique by monitoring the SHG on magnetic and electric domains in ferromagnetic and ferroelectric materials.

12:00
ThF4

FOUR-PHOTON PICOSECOND SPECTROSCOPY OF ULTRATHIN FERROMAGNETIC NI FILMS

Vera M. Petnikova, Konstantin V. Rudenko, Vladimir V. Shuvalov

International Laser Center of M.V. Lomonosov Moscow State University
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The biharmonic pumping technique (BP, tunable laser pulse duration about of 20 ps) has been used to perform experimental measurements of four-photon dispersion curves (the self-diffraction efficiency versus frequency detuning of BP components) of ultrathin ferromagnetic films (Ni, thickness up to 17 nm) and a number of reference metal samples (ultrathin Bi and Au films). The main parameters of investigated samples have been controlled by spontaneous Raman scattering and X-rays reflectometry techniques. To explain a reason of creation of specific two-photon resonance (at the frequency about of 200 cm^{-1}) on a side wing of the experimental dispersion curves for investigated Ni films, we have developed a theoretical model, which takes into account possible quantum-size renormalization of electronic energy spectrum, intraband and interband relaxation processes, selection rules of electronic transitions between magnetic subbands, splitted due to ferromagnetic properties of Ni films, heating of the sample electron subsystem due to absorption of energy of picosecond laser pulses (BP components), etc. An error of the used interpolation of electronic energy spectrum of bulk Ni samples into a full Brilluoen zone was not more than 0.04 eV. In the course of our computer simulation, we have calculated a number of dispersion curves for a wide range of changing fitting parameters of the model. Specific two-photon resonant transitions, which have been experimentally found in the case of Ni films, have been interpreted as direct manifestation of ferromagnetic properties of investigated samples.

12:15
ThF5

SINGLE MOLECULAR SPECTROSCOPY OF DYNAMICAL PROCESSES IN EMBEDDING MATRIX

S. Ya. Kilin[a], A. P. Nizovtsev[a], T. M. Maevskaya[a], V. N. Shatokhin[a], P. R. Berman[b], J. Wrachtrup[c], C. von Borczyskowski[c], L. Fleury[c]

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[b] *University of Michigan, Ann Arbor, Michigan, 48109-1120, USA;*
[c] *Institute of Physics, Technical University Chemnitz, D-09107, Chemnitz, Germany*

We have developed theory interrelating a measured laser-induced fluorescence of a single chromophore guest molecule embedded in low-temperature host matrices with a characteristics of dynamical processes in nanoscopic local environment of the molecule.

Two classes of guest/host systems are considered: (i) organic *crystalline* matrices with spontaneous stochastic proton spin flip-flops dynamics and (ii) *amorphous* matrices where the guest molecule is coupled strongly to a single two level system (TLS) in asymmetric double well potential. In the first case we have studied [1] the fluorescence detected magnetic resonance (FDMR) phenomena on a triplet-state molecule using the model of N random telegraph processes to describe triplet spin dephasing due to frequency fluctuations U' induced by matrix proton spins dynamics. FDMR responses of a molecule to cw/pulsed MW field near-resonant to triplet spin transition are calculated and a wide range of experimental data for single pentacene molecules in *p*-terphenyl crystal are described and model parameters are determined. In the second case we have applied [2] the continuous measurement theory to study a stochastic dynamics of a single molecule+TLS couple and simulate the fluorescence intensity jumps resulted from phonon-assisted tunneling transitions in TLS. Experimental data on fluorescence intensity correlation function of single terrylene molecules in (poly)ethylene matrix are fitted and tunneling rates are determined.

[1] S. Ya. Kilin, A. P. Nizovtsev, P. R. Berman, J. Wrachtrup, C. von Borczyskowski, Phys. Rev. B, 56 (1997) 24; Phys. Rev. B, submitted.
[2] S. Ya. Kilin, T. M. Maevskaya, A. P. Nizovtsev, V. N. Shatokhin, P. R. Berman, J. Wrachtrup, C. von Borczyskowski, L. Fleury, Phys. Rev. A, 57 (1998) to be published.

12:30
ThF6

DC FIELD-INDUCED RESONANCE AND CIRCULAR DICHROISM EFFECTS IN A TWO-COLOR IONIZATION OF ATOMS.

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The resonance on an excited $n'S$−state induced in an atom by a dc electric field in a two-color ionization from the ground nS−state with a resonance photon of the frequency $\omega_1 = \omega_{n'n} - \Delta$, ($\Delta$ is the resonance detuning) and a non-resonance photon of a frequency ω_2, may result in a significant contribution of the interference term in the total cross section,

$$\sigma_{int} \sim F_0^2 \frac{\Gamma}{\Delta^2 + \Gamma^2}[\xi_1 f_1(\mathbf{n}_1, \mathbf{e}_0, \mathbf{e}_2)A_1 + \xi_2 f_2(\mathbf{n}_2, \mathbf{e}_0, \mathbf{e}_1)A_2],$$

which depends on the circular polarization degrees, ξ, of the both photons and the resonant level width Γ. The functions $f_{1,2}$ describe the dependence on the orientation of the photon polarization vectors $\mathbf{e}_{1,2}$ and the directions of propagation $\mathbf{n}_{1,2}$ relative each other and the dc field strength vector, $F_0\mathbf{e}_0$. The factors $A_{1,2}$ in this formula depend on the structure of the concrete atom and the photon frequencies ω_1 and ω_2.

In a close vicinity of resonance, $|\Delta| \approx \Gamma$, the term σ_{int} may cause a rather strong left-right asymmetry in the polarization dependence of the total cross section, which may be determined as the dichroism degree, which in the perturbative region of the involved field strengths may be written as

$$D_{c1(2)} = \frac{\sigma(\xi_{1(2)} = 1) - \sigma(\xi_{1(2)} = -1)}{\sigma(\xi_{1(2)} = 1) + \sigma(\xi_{1(2)} = -1)} = \frac{F_0^2\Gamma}{\Delta^2 + \Gamma^2} d_{c1(2)},$$

with $d_{c1(2)}$, the atomic factor, which may be written in terms of the second-order atomic matrix elements for the bound-bound and bound-free transitions.

Numerical calculations for alkali atoms give the values of $D_{c1(2)} = 0.1 \div 0.5$ in a dc field of few kV/cm. The atomic factors $d_{c1(2)}$ depend strongly on both the magnitude and the phase of atomic matrix elements. The use of this effect seems rather worthwhile for the development of a new method for measuring the atomic level widths and a number of multiphoton spectroscopic properties of atoms.

12:45
ThF7

REGISTRATION OF SPECTRAL REFERENCE LINES BY COHERENT TRANSIENT TECHNIQUE

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Comparative analysis of the contrast and the steepness of spectral reference lines, detected by two nonlinear Doppler free techniques — photon echo in standing waves (PESW) and saturated absorption spectroscopy (SAS) — is performed on identical experimental conditions (over gas pressure and exciting beams geometry) versus intensity of exciting radiation. S/N advantage of PESW technique as compared to SAS method is demonstrated. These conclusions are verified experimentally at $0 \rightarrow 1\ \nu_3$ P(33) A_2^1 SF_6 transition under the action of CW frequency tunable CO_2 laser radiation [1–2].

The increasing role of slow molecules in generation of photon echo response (and hence in reference line formation) at elevated time delays between exciting pulses was registrated as reduction of the photon echo decay rate [3].

References

1. L.S. Vasilenko, N.N. Rubtsova, E.B. Khvorostov, Proceedings SPIE, 1997, v. 3239, p. 332.
2. L.S. Vasilenko, N.N. Rubtsova, Laser Phys., 1997, v. 7, p. 1021.
3. L.S. Vasilenko, N.N. Rubtsova, E.B. Khvorostov, Pis'ma v ZhETF, 1995, v. 62, p. 393.

11:00-13:15 **RED HALL**
ThG - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures IV
Presider *H. Lowdermilk, Lawrence Livermore National Lab., USA*

11:00
ThG1
(Invited)

Paper is not available

11:30
ThG2
(Invited)

Paper is not available

12:00
ThG3

Paper is not available

12:15
ThG4

SIZE EFFECTS IN SECOND HARMONIC GENERATION FROM Si(001)-SiO_2 INTERFACE - MICROSCOPIC INTERFACE EFFECTS AND OPTICAL CASIMIR NONLOCALITY

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M.H. Anderson, P. Wilson, M.C. Downer
Physics Department, University of Texas at Austin, Austin, 78712, USA

Long range (Casimir) interactions, that for example are responsible for the van der Waals force are related with the zero-point fluctuations of the transverse electromagnetic field. In general, the Casimir effects manifest themselves when there are some sort of restrictions for the fluctuation spectrum, i.e. the boundary conditions imposed by a cavity. In this paper we show that so-called optical Casimir nonlocality of surface quadratic susceptibility stemming from electron-electron interaction via quantized electromagnetic field can give rise to a substantial thickness dependence of the optical second harmonic generation (SHG) intensity from Si-SiO_2 interfaces, for oxide thickness in the range of 2-500 nm. The samples used were p-type Si(001) wafers on which a high quality thermal oxide with a variable via etching thickness was grown. The output of Ti:Sapphire laser was used, with wavelength ranged from 700 to 800 nm. SHG measurements were performed for the p-in, p-out combination of polarizations, at an angle of incidence very close to the Brewster angles for the fundamental and SHG radiation. SHG oxide thickness dependence was also measured in index matching fluid.

Summarizing the results, the SHG intensity from Si(001)-SiO_2 interface shows a strong nonmonotonic dependence on the oxide thickness between 2 and 500 nm. The Brewster angle of incidence and p-in, p-out combination of polarizations exclude multiple reflections and, as a consequence, exclude the trivial thickness dependence due to the interference. Suppression of this effect by near-index matching fluid allows to separate microscopic interface effects like strains and photoinduced carriers. The selected thickness dependence can be interpreted to originate from the optical (Casimir) nonlocality stemming from the thickness-dependent electron-electron interaction via virtual photons of the quantized electromagnetic field.

12:30
ThG5

GROWTH AND OPTICAL QUALITY OF LARGE (55 cm) KDP AND DKDP CRYSTALS

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KDP crystals with sizes up to 450 mm had been grown previously in crystallizers with a volume of 1000 L at growth rates of up to 10-20 mm/day. First measurements of optical quality (depolarization loss, light absorption, wave front distortion and damage threshold) [1] showed that, in general, large rapidly grown crystals can be as good as small crystals grown both by the traditional or rapid techniques [2].

In this paper we report the recent results on rapid growth of KDP and DKDP (90% deuterated) crystals of up to 57x57 cm2 in crossection and up to 55 cm in height. Crystals were grown by the temperature reduction method starting from a saturation point 65-75=B0C to room temperature and lower, down to 8-10=B0C. This progress was made possible due to the scientific and technical research performed to understand the problems connected with scaling the growth process. The effect of different factors, such as impurities, stress, growth rate and regeneration conditions, have been investigated for the case of large crystals. The design of the 1000 L crystallizer, as well as the design of the platform-crystal holder have been modified to provide the conditions required for the growth of 250 kg crystals. All growth tanks were equipped with constant filtration systems, specially designed for operating at the high supersaturations needed for fast growth. It has been proven that the constant filtration was one of the important conditions required for obtaining crystals of high damage threshold and optical uniformity.=20

37x37 cm2 and 41x41 cm2 single crystal plates have been cut from the grown crystals for optical measurements and use on Beamlet, the NIF prototype, currently operating at LLNL.

1. N.P.Zaitseva, J.J.De Yoreo, M.R.Dehaven, R.L.Vital, L.M.Carman and H.R.Spears, Rapid Growth of Large-Scale (40-55 cm) KDPcrystals, SPIE Vol.3047 (1997) 404-414.
2. J. J. De Yoreo, Z.U. Rek, N.P. Zaitseva, B.W. Woods and T.A. Land, "Sources of optical distortion in rapidly grown crystals of KH2PO4", J.Cryst.Growth 166 (1996) 291-297.\

12:45
ThG6
(Invited)

Spectroscopy Second Harmonic Generation in $(Si_mGe_n)_p$ Superlattices

Chun Zhang, Xudong Xiao, N. Wang, K. K. Fung, M. M. T. Loy,
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International Laser Center, Physics, Moscow State University, Moscow 119899, Russia
Zhenghao Chen and Junming Zhou
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Si_mGe_n strained layer superlattices (SLS) has attracted considerable attention because they might possess large second-order optical nonlinearity and are integrable with Si-based technology. However, prior woks concentrated on the SH contribution from Si-Ge interfaces and found that the theoretical prediction of large $\chi^{(2)}$ could hardly be realized in practice.[1] To approach this problem more quantitatively, we have measured spectroscopic SHG from a variety of $(Ge_mSi_n)_p$ SLS samples. The measured spectrum of $\chi^{(2)}_{311}(\omega)$ for $(Ge_5Si_5)_3$ SLS, for example, shows a resonance band peaked at 1.68 eV (fundamental photo energy) with a maximum $\chi^{(2)}_{311}$ value of 1.3×10^{-6} esu. Due to the similarity of the spectrum to that of the Si/SiO_2 interface,[2] we attribute a same origin, namely, a few layers of strained Si-Si bonds in the superlattices to be responsible for our observed SH resonance. In addition, the magnitude of $\chi^{(2)}$ is consistent with the calculation result of strain induced nonlinearity at a Si-Si bond,[3] which is comparable to that of a Si-Ge bond. Both the resonance response and the strength of $\chi^{(2)}(\omega)$ suggest that in addition to the Si-Ge interfaces, the strained Si-Si bonds in the superlattices also play an important role to contribute SHG.

References:

[1]D. J. Bottomley, J. -M. Baribeau, and H. M. van Driel, Phys. Rev. B **50**, 8564 (1994).
[2]C. Meyer, G. Lüpke, U. Emmerichs, F. Wolter, and H. Kurz, Phys. Rev. Lett. **74**, 3001 (1995).
[3]S. V. Govorkov, V. I. Emel'yanov, N. I. Koroteev, G. I. Petrov, I. L. Shumay, and V. V. Yakovlev, J. Opt. Soc. Am. B **6**, 1117 (1989).

11:00-13:15 **BEIGE HALL**
ThH - High-Precision Measurements in Optics IV
Presider *D. Meschede, Univ., of Bonn, Germany*

11:00
ThH1 Direct Observation of Charge Gratings in Photorefractive Materials Using Force Microscopy
(Invited)

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Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, D-85748 Garching, Germany

Photorefractive materials are of growing interest because of their applications as high-density optical storage media. There have, however, so far only been a few attempts to obtain direct images of the stored information. Since optical methods were used in these experiments the spatial resolution was limited by the wavelength. A completely different approach is provided by scanning probe microscopy. Using electrostatic force imaging it is possible to record charge distributions on insulating materials with high sensitivity, and a lateral resolution as small as a few tens of nm. Like all scanning probe techniques the method is extremely surface sensitive.

Using electrostatic force microscopy we investigate charge gratings on $Bi_{12}SiO_{20}$ and $BaTiO_3$ crystals, and on thin films of photorefractive polymers. The gratings are generated using two laser beams at 514 nm in a total-internal-reflection geometry. Stored charge gratings as well as gratings in steady state (writing beams on) are imaged. These images contain information about the amplitude, the profile and the polarity of the grating lines. In addition the charge distributions show a microstructure which is partly connected to topographical surface features and partly to crystal imperfections.

This method allows, for the first time, a detailed study of the profiles of charge gratings in photorefractive materials. The time development of such profiles in $Bi_{12}SiO_{20}$ crystals is followed into the saturation regime by varying the writing time. The shape of saturated profiles is strongly dependent on the grating constant and the modulation index of the light grating. Starting from a nearly sinusoidal shape, the negative grating lines become extremely narrow as both parameters are increased. These observations are understood using simplified solutions of the Kukhtarev equations. The profiles of charge gratings in equilibrium with the writing beams differ significantly in amplitude as well as in width from the stored gratings. These effects are explained by the presence of shallow traps for the charge carriers in the crystal.

11:30
ThH2
(Invited)

Paper is not available

12:00
ThH3
(Invited)

The optics beyond the diffraction limit

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Summary

Near-field optics, a new direction of science and technology, allows imaging and modification of surfaces with resolution of nanometer range. General problems of this direction is considered in the paper. The emphasis is on non-linear optical phenomena and photo-physical aspects of the laser interaction with matter localized in the near field.

Common component of near-field devices is an optical probe. The probe is made of a tapered fiber which is coated with metal and has a small aperture at the tip. General structure of the field in the probe is considered. Peculiarities of the near field structure near the exit aperture is discussed taking into account radiative and non-radiative waves.

The problem of optical resistance of the probe becomes very important in the case of relatively high intensities of the passing laser radiation. This is due to the fact that only a *little fraction* (~10^{-6}- 10^{-4}) *of the radiation energy reaches the sample* surface. The most part of the energy is absorbed in the metal coating.
The developed model of action of passing laser radiation on the probe describes heating of the probe taking into consideration different kinds of heat loss. Possible mechanisms of feedback formation in the system of near-field probe and the sample is discussed. Redistribution of the filed near the probe tip and certain non-linear effects may result in localization of the light action in the region, whose size is comparable to the tip diameter.

The paper suggests the basis of heat model of interaction of intensive laser radiation with the surface in the localized near-field of the probe. It has been shown that the principle parameter, which determines character of this interaction, is a ratio of the tip diameter and free path length of non-equilibrium carriers generated by the light. It has also been shown that "diffusion" mode of transformation of absorbed energy to heat leads considerable delocalization of near-field action. Main equations describing non-equilibrium photo-excitation and heating of the sample have been derived and discussed.

The obtained results allows one to estimate spatial resolution and actual applicability of near-field optics in nano-lithography and ultra-high optical data recording.

12:30
ThH4

Spectro-temporal method for achievement of superresolution in studies of ultrashort optical signals

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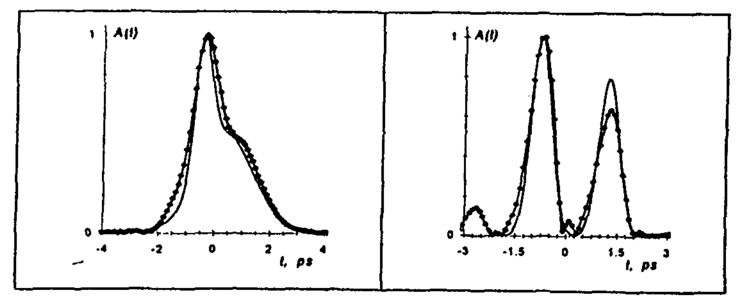
A new method for measuring the temporal characteristics of ultrashort optical signals is presented. The method includes a special mathematical treatment of time-resolved spectrum recorded on the screen of an image converter camera (ICC). The feasibility of the mathematical procedure is based on the high spectral resolution that permits to restore the amplitudes and phases of the Fourier spectrum for measured signal. This provides the possibility to reconstruct temporal structure of the signal with the effective resolution much higher than that of ICC. Simulations of the measurement procedure and signal reconstruction are performed numerically taking into account noises intrinsic for the detecting system. Two examples of the reconstructed (line with dots) and initial ultrashort optical signals are given in the figures below. The simulations are fulfilled supposing the response time of the ICC (at half-intensity level) to be equal 25 ps.



12:45
ThH5
(Invited)

High power self-induced beam propagation effects and their consequences on Gravitational Wave Interferometry

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Large scale interferometric gravitational wave detectors currently under construction (such as those being developed by LIGO, VIRGO, GEO, TAMA, and ACIGA) will use frequency and amplitude stabilized high power (10 W) continuous wave lasers and high precision interferometry for sensitive readout of the gravitational wave signal. The initial displacement sensitivity goal of 10^-19 m/Hz^1/2 places stringent requirements on excess noise and modal contamination induced by the propagation of high power radiation through transmissive optical elements in a high precision interferometer. In this talk, we give an overview of the LIGO Project and its current status with an emphasis on how high power self-induced beam propagation effects (such as thermal lensing, thermally-induced depolarization, optical damage) can be manifested in LIGO and what impact they have on interferometer sensitivities. We will present experimental and theoretical investigations of these effects and discuss their consequences for current and future gravitational wave interferometers.

11:00-12:30 **PRESIDENT'S HALL**
ThI-Basic Concepts of Laser Chemistry,Biophysics and Biomedicine IV
Presider *A.Yu. Chikishev, M.V.Lomonosov Moscow State Univ., Russia*

11:00
ThI1
(Invited)

FAST CONFORMATIONAL CHANGE IN THE S_1 STATE: PICOSECOND TIME-RESOLVED ABSORPTION AND RESONANCE RAMAN STUDY OF DIBENZO-DERIVATIVES OF SEVEN-MEMBERED RINGS

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3-4-1 Okubo, Shinjuku-ku, Tokyo 169, Japan

We have measured picosecond time-resolved absorption and resonance Raman spectra of dibenzazepine (DBA), dibenzoxepine (DBO) and dibenzotropone (DBT) for the purpose of obtaining information on the structure and dynamics in the electronic excited states. At 2 ps after UV excitation DBA exhibited a broad absorption band at 523 nm (bandwidth: ~50 nm) in cyclohexane which was quickly shifted to shorter wavelength with concomitant bandwidth narrowing. At about 100 ps the band stopped shifting and narrowing at 511 nm (bandwidth: ~25 nm). Then, started a fast decrease of the intensity and the 511 nm band disappeared at about 1 ns. We interpret the spectral change as follows: DBA is known to take a bent structure in the S_0 state. In the S_1 state, however, the planar structure is more stable than the bent structure. The fast spectral change is ascribable to the fast conformational change from the less stable bent structure of the Franck-Condon state to the most stable planar structure in the S_1 state. Support for this explanation is provided by our observation of a large Stokes shift of the fluorescence band at 601 nm. The Raman band at 1580 cm^{-1} which is assignable to the ethylenic C=C stretch of the S_1 state was also shifted to 1591 cm^{-1} in the same time-region. Spectral changes of DBO were very similar to those of DBA, but DBT exhibited quite different spectral changes possibly due to the presence of a carbonyl group.

11:30
ThI2

FEMTOSECOND MOLECULAR-ION DISSOCIATION DYNAMICS IN SOLUTION

M.V.Alfimov[1], A.V.Balakin[2], A.Yu.Chikishev[2], S.P.Gromov[1], O.A.Federova[1], A.V.Feofanov[3], N.I.Koroteev[2], I.R.Nabiev[3], V.A.Oleinikov[3], A.V.Pakulev[2], A.Yu.Resniansky[2], A.P.Shkurinov[2], A.I.Ianoul[3].

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Studies of photochromic materials is continuously growing because its interesting photochemistry and its potential applications in electronics and other important fields. In this presentation we describe kinetic results obtained by femtosecond transient absorption spectroscopy with the crown countering spirooxazines compounds. We also present results of studies of crown containing spirooxazine and steryl dyes with the picosecond time-resolved and steady-state surface-enhanced Raman spectroscopes (SERS).

In addition to the typical areas of the spirooxazines studies, such as distinction of different molecular isomers, studies of participation of singlet and triplet electronic states in the photochemical reaction and description of the reaction intermediates in this presentation we studied their metal ions complexation which became the point of particular interest. It concerned with important properties of selectivity of molecular systems containing crown group to the certain metal ions. Our observations demonstrate that spirooxazine counting crown group is less complexing in the excited electronic state that in the ground state. It gives direct evidence for the mechanism of the reduction of nitrogen electron-donating character upon electronic excitation. Furthermore, our experiments provide evidence for rapid evolution of the spirooxazine complex ground state with two-step or two state mechanism.

11:45
ThI3

PHOTOTRANSFORMATION AND PHOTOINDUCED OXYGEN-UPTAKE IN C_{60} FILMS IRRADIATED BY FEMTOSECOND LASER PULSES

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Photoinduced polymerization (PP) has been investigated in thin (0.2 - 1 mcm) C_{60} films with different content of oxygen. Irradiation sources were CW Ar laser (514 nm, 10-300 W/cm^2) and 82 MHz repetition rate 100 fs laser pulses at 395 nm (average power density 10-300W/cm^2). The samples were hold at ambient conditions before and during the experiment. The onset of PP was controlled by appearing of dark spot in the irradiated region. Micro-Raman investigation of the spots was done in the spectral region of 200-1800 cm^{-1} after irradiation.

It was observed that PP does not occur in the sample with completely oxygen-filled octahedral sites under irradiation by any source. For the observation of PP in 2000A film, deposited at high vacuum, about 3 times more absorbed quanta were demanded in the case of femtosecond irradiation than in CW case. Raman spectra were sufficiently different in these two cases also. From comparing of Raman spectra it was concluded that their change in CW irradiation case was due to PP, oxygen uptake and carbonyl formation and only due to PP when femtosecond pulses were used. All the peculiarities of femtosecond irradiation except for absence of uptake can be explained by the only reason - low intersystem conversion efficiency due to high excitation density.

This work is partially supported by CRDF Grant N RP-2-154.

12:00
ThI4

FEMTO/PICOSECOND DYNAMICS OF ELECTRON AND ENERGY TRANSFER IN MULTIPORPHYRIN MODEL ARRAYS

E.I.Zenkevich[1], S.M.Bachilo[1], A.M.Shulga[1], U.Rempel[2], Ch. von Borczyskowski[2]

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In relation to the mechanisms of electronic excitation energy transfer (EEET) and photoinduced electron transfer (ET) in photosynthetic systems *in vivo*, we carried out extensive cw, picosecond ($\Delta_{1/2}$=30ps) time-resolved fluorescent and femtosecond ($\Delta_{1/2} \approx$ 280 fs) pump-probe spectroscopic investigations on a series of biomimetic model systems (with well-defined structure and controllable number and photophysical properties of interacting subunits) in methycyclohexane, toluene at 77-300 K. The formation of the systems is based on the combination of two principally different approaches: i) chemical synthesis of Zn-octaethylporphyrin dimer, ZnOEP-Ph-ZnOEP (system I), with phenyl spacer (Ph), and corresponding D-A moieties ZnOEP-Ph-ZnOEP-Sp-A (systems II), where an electron acceptor A (*p*-benzoquinone, antraquinone, pyromellitimide) is covalently linked to the dimer; ii) non-covalent two-point coordination of (ZnOEP)Ph(ZnOEP) with pyridyl substituted tetrapyrrolic extra-ligands leading to the formation of self-assembled triads with additional electron/energy acceptors (systems III).

At 298 K in non-polar methylcyclohexane when transition from I to II the dimer fluorescence quenching (up to ~30 times) is observed and becomes stronger upon the environment polarity rising. It reveals in S_1 states lifetimes shortening from ns to a few ps. In some cases this quenching is accompanied by the appearance of ion-radical form absorption bands caused by ET process. For the system III with di-pyridyl-pentafluor-substituted porphyrin extra-ligand, P, a strong P fluorescence quenching (>100 times in the 77-298 K range) is a result of the photoinduced ET with τ = 0.6±0.2 ps. In this case ET process is faster than EEET (~1.6 ps).

On the base of the experimental data being obtained the whole scheme of the excitation energy deactivation pathways in the systems of interest is analysed.

12:15
ThI5

CHARGE RECOMBINATION IN PHOTOEXCITED CHARGE TRANSFER COMPLEXES BETWEEN METHYL-VIOLOGEN AND NAPHTHALENE. STUDY BY PICOSECOND TRANSIENT GRATING SPECTROSCOPY.

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SUMMARY.

The relaxation of photoexcited charge transfer complexes between methyl-viologen (MV^{2+}) and naphthalene (NPH) in methanol was studied by polarized transient grating spectroscopy (TGS). The mixture of MV^{2+} and NPH at concentrations 0.1 M in methanol was excited by picosecond laser pulse at λ_{ex}=359 nm, and probed by delayed pulse at λ_p=539 nm. There was observed TGS diffraction signal due to the occurrence of $MV^{+\cdot}$ absorption band around 605 nm in the photoexcited charge transfer complex MV^+--NPH^+. The lifetime of the excited complex is τ_{ex}=65±10 ps.

The optical anisotropy of the TGS diffracted signal shows the decay time τ_a=61±12 ps. The fact, that this time is close to the calculated rotational correlation time of MV^+ fragment in methanol, allows to suggest that the kinetics of the anisotropic response is caused mainly by the orientational rotational dynamics of MV^+ fragment in MV^+--NPH^+ complex.

The observed low initial value of the anisotropy signal is possible due to the specific orientation between the transition moment vectors of the transitions, which occur during the excitation and probing after the excitation respectively.

This work was financially supported by the Russian Foundation for Basic Research (Project № 95-03-08247a).

11:00-13:15 **BLUE HALL**

ThJ - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics IV

Presider *V.D. Taranukhin, M.V.Lomonosov Moscow State Univ., Russia*

11:00
ThJ1

"Semiclassical Approach to Strong Field Dissociation of Molecules"

Misha Ivanov

Femtosecond Program, SIMS, NRC of Canada
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I will describe the physical mechanism and a semiclassical modeling of dissociation of homonuclear and heteronuclear diatomic molecular ions in strong infrared laser fields, using examples of HCl+ and H2+. In low-frequency fields small ratio of the laser frequency to that of electronic excitation can be used to introduce time-dependent Born-Oppenheimer potential energy surfaces - eigenstates of the instantaneous time-dependent Hamiltonian H(t) that adiabatically follow slow oscillations of the low-frequency electric field. Nuclear dynamics occurs on these *adiabatic* surfaces. In strong mid-infrared fields nuclear motion during one laser cycle is significant - several Angstroms for H2+. It is imperative to follow nuclear dynamics inside a laser cycle to gain physical understanding of molecular response to strong mid-infrared fields. That is why introducing adiabatic potential energy surfaces allows one to built a physically transparent picture of molecular dissociation.

This method also allows one to minimize errors introduced by combining quantum description of electron dynamics with the classical description of nuclear motion. With more than one potential energy surface involved, classical motion of the nuclei on a given surface is accompanied by hopping of nuclear trajectory between the surfaces. If a trajectory has more than one chance to hop, a very difficult issue of adding successive hops arises. For time-dependent Hamiltonians hopping meets with another difficulty - in general no unambiguous conservation principle can be applied. Incorrect addition of electronic amplitudes after successive hops is the main cause of failure of combined classical-quantum description of molecular dynamics. I will discuss possible ways to remedy this problem.

11:15
ThJ2

11:30
ThJ3
(Invited)

COLLISION OF HIGH ENERGY ELECTRONS AND PHOTONS WITH SUPER INTENSE LASER PULSES

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The opportunity of testing of nonlinear quantum-electrodynamic effects emerged recently when very powerful table-top lasers were made. The experiment on study of QED at critical field strength [1] is underway at SLAC (Stanford) now. In this connection we consider the processes of photon emission by an electron and e^-e^+ pair production by a high energy photon colliding with one- and two-colour laser pulses of high intensity. The plane bichromatic wave model is employed for description of two-colour laser pulse. It is demonstrated that the probability of the process in this case essentially depends on the intensity distribution between field components and at any distribution the probability exceeds those in the monochromatic field of the same intensity. Usually the plane monochromatic wave model is used for the description of one-colour laser field. However super intense laser pulses can be obtained only by means of strong focusing and very small duration of the pulse. That is why one should take into account nonhomogeneity of the laser pulse. We developed the method for the calculation of the probability of QED effects arising in the interaction of high energy photons and electrons with the field of a short focused laser pulse. It is based on the summation of the contributions of various points of the laser pulse to the probability amplitude. Spectral-angular and spectral distributions of the probability of the processes are calculated. They differ essentially from those of monochromatic field. The difference is manifested in the broadening of harmonics and the appearance of the fine structure of harmonics. The mass spectrum of produced e^-e^+ pairs is calculated.

References

1. Bula, C., Lu, C., McDonald, K.T., *et al.*, 1991, *Study of QED at Critical Field Strength in Intense Laser-High Energy Electron Collision at SLAC* (Princeton: Tennessee Collaboration E-144).

12:00
ThJ4
(Invited)

MULTIELECTRON DISSOCIATIVE IONIZATION OF DIATOMIC MOLECULES IN STRONG LASER FIELDS

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The discovery of multielectron dissociative ionization (MEDI) of diatomic molecules in intense ($\geq 10^{14}$ W/cm^2) laser fields [1] was soon followed by the realisation that conventional perturbation theory was inapplicable. To fill this void a semi-classical, field ionization, Coulomb explosion (FICE) model was proposed [2]. Recently the FICE model has been developed into a more quantitative form [3–5].

Double ionization of H_2 is particularly interesting because the H_2^+ ion is amenable to rigorous theory [6]. The (H, H+) and (H+, H+) fragmentation channels can be distinguished experimentally using the covariance mapping technique [7]. The increase of the proton kinetic energy with the laser intensity in the (H+, H+) channel but not the (H, H+) channel can be explained by the focal volume effect [8]. Detailed modelling of the focal volume shows that below 10^{14} W/cm^2 the first ionization of H_2 is the limiting step of the whole MEDI process.

The peaking of MEDI ions along the laser *E*-field was initially explained simply as a geometric effect [2], but experiments on I_2 showed that there are no ions ejected perpendicular to the *E*-field [9]. Since it was difficult to see how a geometric effect could explain this behaviour, an active alignment (rotation) of even the heaviest molecules by the laser field was invoked. However, our latest data [unpublished] show that iodine atomic ions *are* ejected perpendicularly to the *E*-field, provided that the laser intensity is about an order of magnitude above the appearance intensity. This is fully consistent with the geometrical effect; no other process needs to be invoked to explain the I_2 data. On the other hand, H_2 gives much sharper angular distributions, showing that lighter molecules are indeed reoriented and moreover exhibit two effects in addition to the geometric one: a rise-time effect and a torque effect.

At the fundamental level, future research needs to elucidate the initial stages of the MEDI process. Applications of femtosecond pulses include mass spectrometry of unstable molecules, coherent control of chemical reactions and monitoring molecular dynamics.

[1] L J Frasinski *et al*, *Phys. Rev. Letters* **58** 2424–2427 (1987)
[2] K Codling, L J Frasinski and P A Hatherly, *J. Phys. B: At. Mol. Opt. Phys.* **22** L321–L327 (1989)
[3] J H Posthumus *et al*, *J. Phys. B: At. Mol. Opt. Phys.* **28** L349–L353 (1995)
[4] T Seideman, M Yu Ivanov and P B Corkum, *Phys. Rev. Letters* **75** 2819–2822 (1995)
[5] T Zuo and A D Bandrauk, *Phys. Rev.* A **52** R2511–R2514 (1995)
[6] A Giusti-Suzor *et al*, *J. Phys. B: At. Mol. Opt. Phys.* **28** 309–339 (1995)
[7] L J Frasinski, K Codling and P A Hatherly, *Science* **246** 1029–1031 (1989)
[8] M R Thompson *et al*, *J. Phys. B: At. Mol. Opt. Phys.* **30** 5755–5772 (1997)
[9] D T Strickland *et al*, *Phys. Rev. Letters* **68** 2755–2758 (1992)

12:30
ThJ5
(Invited)

Non-linear Optics and Damage of Vacuum Polarized by High-Power Laser Radiation

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Modern laser technique allows to generate radiation with intensity up to 10^{21} W/cm^2. Although this value is considerably lower than the electron-positron pairs appearance threshold in vacuum - 10^{29} W/cm^2, the vacuum polarization for such fields has a considerable influence on parameters of radiation that propagates in this medium. Therefore investigation of quantum-electrodynamics processes in super strong laser fields becomes an important task.

By the present time a certain number of non-linear optical phenomena was studied using the Heisenberg-Euler approximation [1]. Among them are four-wave interaction, self-focusing and polarization of radiation turning [2,3]. This approximation allows to analyze all the above mentioned phenomena in local limit. However the length of interaction of radiation with vacuum is big enough to conclude that non-local terms are significant in studying these effects. Thus we refuse from the Heisenberg-Euler approximation and take into consideration the process of the vacuum polarization by the laser radiation. This is done in the frames of more accurate quasi-classical approximation of quantum-electrodynamics. As a result the more exact description of the non-liner optical processes was received. In particular in the present work the four-wave interaction and the generation of radiation harmonics phenomena are investigated. The same method id used in the work for considering an affect of exciting of vacuum by the Coulomb charge field on the vacuum "damage" threshold.

The technique for calculating the characteristics of the electron-positron pairs appearance process in the strong laser fields is developed. It allows to determine an explicit dependence of these characteristics on parameter $(eE)/(m\omega)$. Here e is the electron charge, m is electron mass, ω is the laser field frequency and E is the laser field intensity. We also present the probabilities of the electron-positron pairs appearance for different cases of parameter $(eE)/(m\omega)$. The quantity of electron-positron pairs that have maximum probability to emerge for the fixed parameters of laser radiation is found. Due to acceleration of particles in the laser field an avalanche-like process of the electron-positron pairs emerging arises. It is the so-called vacuum "damage". The characterizing this effect quantities were evaluated.

References

1. Heizenberg W., Euler H., Zs.f Phys., 98, p.714, 1936.
2. Aleksandrov E.B., Anselm A.A., Moskalev A.N. Zh.E.T.Fiz., 89, p.1181, 1985.
3. Rosanov N.N. Zh.E.T.Fiz, 103, p.1996, 1993.

13:00
ThJ6

NONLINEAR PROPAGATION OF HIGH-POWER ELECTROMAGNETIC RADIATION IN VACUUM

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There are the following two mechanisms of a pure vacuum optical nonlinearity. First, it is a quantum-electrodynamical phenomenon of electron-positron vacuum polarization. Second, it is a classical (Einsteinian) gravitation induced by electromagnetic radiation.

In the paper, a theory of propagation of high-power electromagnetic radiation in such a vacuum is developed. For the quantum-electrodynamical mechanism, the Heisenberg-Euler theory was modified to take into account vacuum dispersion which is important for ultrashort radiation pulses. An approximate parabolic equation is deduced that describes radiation diffraction, dispersion, and vacuum nonlinearity. I show existence of dark optical solitons in the vacuum.

For the gravitational mechanism, additionally to the Maxwell's equations, the linearized Einstein/s equations of gravitation are involved (the first approximation of perturbation theory which is valid for weak gravitational fields). The parabolic equation is deduced and its approximate solution is received which describes focusing and defocusing of a weak probe radiation on the background of a strong radiation beam/pulse.

14:30-16:45 **GREEN HALL**

ThK - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies I

Presider *Yu.N. Denisiuk, Vavilov State Optical Inst., Russia*

14:30 ThK1 (Keynote)

A Status Report on Holographic Data Storage

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Holographic data storage claims the potential of high storage densities, high data rates and associative retrieval of the stored information. Storage densities of the order of TB/ccm should be feasible, at least in principle. The page oriented character of holographic data storage with its potential for highly parallel data input and output should allow very high aggregate data rates for this data storage technique and using standard optical techniques the stored data should be content addressable.

These claims have been made for many years and would make holographic data storage, if affordable, the prime data storage technique. Despite years of research in this field by a large number of groups around the globe no commercially viable product is on the market today and lab demonstrations have not yet been convincing. Disk drives, on the other hand have been getting better in performance and lower in cost. Is there hope for a viable holographic data storage technology?

The basic physical limitations of this optical storage scheme, recent progress in components, systems and recording materials is reviewed and the open issues are discussed.

15:15 ThK2 (Invited)

HOLOGRAPHIC MEMORY. DEVELOPMENT AND APPLICATIONS

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Summary

The paper studies the information capacity of a three-dimensional holographic carrier used in multiple data recording with hologram superposition. An expression for the storage density that defines the ultimate capabilities of holographic memory systems is given with consideration for noise.

A multilayer structure with independent data recording in each layer is suggested as a volume holographic carrier. The noise of this data carrier is investigated and the best conditions providing the lowest reading error rate are found. The optimization procedure also takes into consideration the photodetector parameters and the laser light distribution during hologram recording and reading. The holographic memory systems are demonstrated to offer a possibility for superresolution.

The current state and future of bit-by-bit memories, including three-dimensional systems and systems using the near-field technology, are considered. The possibility of increasing the storage density of such systems is discussed.

With consideration for future development of bit-by-bit storage systems, the most prospective fields of holographic memory applications are determined and discussed. The paper states the basic requirements on such data storage systems and the problems to be solved.

15:45
ThK3
(Invited)

High Density Disc Storage by Multiplexed Microholograms

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The new concept of microholographic data storage allows storage capacities of up to 100 GB on a DVD-sized disc /1/. In this concept the information is stored bitwise in form of microholograms. High storage densities can be achieved by combining multiplexing techniques and multilayer storage. Microholograms can be stored overlapping in the same volume by using angle multiplexing, wavelength multiplexing or the combination of both. Such storage of multiple information bits in one single position on the disc increases the storage capacity as well as the data transfer rates by the multiplex factor. A theoretical model for focused gaussian-beams is proposed. The size and form of microholographic gratings are calculated for different focussing conditions. The microholograms are strongly confined and therefore can be arranged very close to one another. Their limited depth allows an easy realization of a multilayer systems similar to those presently developed for DVD.

In all experiments DuPont's Omnidex HRF-800 photopolymer films with 20 µm thickness are used. For single-color holography a Helium-Neon laser operating at $\lambda = 632.8$ nm was employed as light source. Two lenses generate a gaussian beam waist, where the holograms are recorded using a Denisyuk-arrangement. The local distribution of the diffraction efficiency was investigated by applying a confocal scanning microscope setup. Holograms with a radius of 1.8 µm and 12 µm depth have been recorded. The maximum diffraction efficiency in this case was about 0.4 %, due to shrinkage of the polymer and a resulting wavelength-misplacement. Larger diffraction efficiencies up to 50 % are observed with single-color holograms having a spot-size between 30 µm and 150 µm. Wavelength multiplexing of micro-bragg gratings with a diameter down to 30µm and diffraction efficiencies up to 7 % is demonstrated. All colors are clearly resolved in transmittance spectra. The linewidths $\Delta\lambda$ are less than 10 nm (FWHM). Baking the holograms for 1h at 120 °C increases the diffraction efficiency from 25 % to 50 %. The spectral response of the microholograms broadens by a factor 2. The polymers allow recording rates of 10 GBit/s since we were able to record bright holograms using 80 ps pulses.

/1/ H.J. Eichler, S. Diez, R. Elschner, R. Macdonald, R. Schulz, A. Wappelt, „High density disk storage by multiplexed microholograms", SPIE Vol. 3109, p. 239 (1997)

16:15
ThK4
(Invited)

On the Quest for New Inorganic Host-Lattices for Hyperfine Optical Hole Burning

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Application of optical hole burning led to demonstrations of fast and efficient real-time holographic storage devices. The storage capacity promises to be larger by a few orders of magnitude when compared to e.g. semiconductor or magneto-optic memories. To date, a number of organic based (polymeric) materials and some inorganic host-lattices for optical hole burning on lanthanide (Ln) ions have been investigated. Apart from processes where the valence state of Ln ions is converted by a writing beam, another reservoir for Ln ions is given by *hyperfine levels* of the electronic ground state. In this case a given ion is resonant with the pump frequency on only one of the allowed transitions among the hyperfine levels of both the ground and excited state, but it may relax by another allowed pathway to a different ground state level. This type of a mechanism (*hyperfine optical hole burning* = H-OHB) can produce spectral holes. For optical storage applications several parameters (for a summary and further refs., see [1]) essentially depend on the host-lattice. In this work we concentrate on a strategy of decreasing spin contributions to the homogeneous width Γ_{hom} by *a chemical exploration of host-lattices without or with low nuclear moments*. It has been demonstrated that the application of external magnetic fields can lower Γ_{hom} down to 100-200 Hz. It is hence expected that nuclear spin-free host lattices may give rise to a Γ_{hom} of the same order. For our study we considered Ln ions such as Pr^{3+}, Eu^{3+} and Sm^{2+}. Based on elements given by their natural abundance there is quite a small number of building units to assemble host-lattices which require (i) a low spin concentration, (ii) a homovalent substitution by Ln ions and (iii) a site symmetry being low enough for intense absorption. Because of the absence of a M^{3+} (μ_1 : small) ions suitable for a substitution by Ln^{3+} this quest turned out to be rather difficult. Consideration of about 30 different lattices and final analysis of $CaTiSiO_5:Pr^{3+}$ and $Ca_2ZnSi_2O_7:Pr^{3+}$ [2] yielded low temperature spectra with significant broadening due to a disorder induced by a mechanism of heterovalent substitution. In the case of $CaWO_4$:Eu an annealing at high O_2 pressure was needed in order to convert Eu^{2+} back into Eu^{3+}. More promising results have been obtained just recently, when we succeeded in doping $Ca_2MgSi_2O_7$ with Sm^{2+}.

[1] A. Caprez, P. Meyer, P. Mikhail, J. Hulliger, Mater. Res. Bull. 32 (1997) 1045-1054; [2] A. Caprez, P. Mikhail, J. Hulliger, J. Crystal Growth 183 (1998) 205-216.

14:30-16:45 **RED HALL**

ThL - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures V

Presider *A.A. Kaminskii, Inst. of Crystallography, Russia*

14:30
ThL1
(Invited)

NONLINEAR OPTICAL CRYSTALS: PRINCIPLES OF SEARCH OF NEW PROMISING MATERIALS

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In the modern state of the nonlinear optics of condensed matter a primary problem is the interrelation into microscopic crystal chemical structure and macroscopic physical properties of multicomponent crystal media. At the present time the physical properties of many oxide crystals are determined more detail. The extent of acentricity of elementary cell and value of its nonlinear property are conditioned in great part on structural chemical parameters.

In this work is carried out the system analysis of the dependence of second order nonlinear optical susceptibilities from the lengths of basic chemical bonds of binary and ternary oxide crystals. It has been found that the most effective noncentresymmetric binary oxide crystals are localized in the space of chemical bond lengths on rosette of the two extended ellipses, having vertical and horizontal focal axis crossed in their bottom focus on the line of equal distances or the line of the symmetry of two ellipses. At the same time the effective acentric ternary oxide crystals are arranged on surface of four ellipsoids that are formed by turn and small deformation of above mentioned ellipses relative focal and minor axis. The maximum of acentric properties is take the place at equality of cation diameters with the sizes of tetrahedral and octahedral hollows of anion sublattices into oxide, chalcogenide, pnictide and other crystals.

The performed analysis is the development of the structural chemical aspects of crystal physics of condensed matter. This method correlates the piezoelectric, electrooptic and other nonlinear optical properties into crystal chemical parameters of oxide crystal compounds. The presented results are important for purposeful search and synthesis of new acentric crystals with high nonlinear optical properties.

15:00
ThL2
(Invited)

Nonlinear properties of the Cr-doped crystals.

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The spectroscopic investigations of the Cr-doped garnet crystals have resulted in the discovery of the effect of the polarizing anisotropy of the saturable absorption in optically isotropic crystal media. It was shown that in the optically isotropic YAG crystal one could observe the induced nonlinear anisotropy of the absorption under the laser beam propagation with 1 μm wavelength. This phenomenon was studied both for Cr:YAG and for the other garnet hosts (YSGG, GSGG etc.) both for the cases of the short probe pulse (shorter then the Cr ion excited state lifetime) and for the CW probe mode.

The effect of the polarizing anisotropy of the absorption saturation was used for the controlling of the output characteristics of the Nd-laser (polarization properties of the output, energy, pulswidth and the repetition rate of the giant pulses).

The state of art of the application of crystals with Cr^{4+} centers is the use of it as nonlinear media for four-wave mixing in Nd-lasers. The process of the four-wave mixing occurs in the bulk of the Cr-doped crystalline passive Q-switch of the laser. During the study of the degenerate four-wave mixing in the Cr-doped crystals we observed relatively small values of the reflection coefficient of the OPC-mirrors (optical phase conjugation) - not exceeded ~1%. Nevertheless the application of these nonlinear media directly in the loop resonator allows to organize the intracavity compensation of the laser beam distortions and to improve the polarization, spatial and energetic characteristics of the laser output. The four-wave mixing was shown both theoretically and experimentally to take place on the dynamical holographic gratings of the refraction index formed in the bulk of the crystal during the laser pulse build-up.

15:30
ThL3
(Invited)

Paper is not available

16:00
ThL4
(Invited)

Formation of Grating Structures on Semiconductor Surfaces and Sub-surfaces with High-power Laser Interference

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In this paper, we report the formation of surface gratings on silicon and GaAs and the grating-like structures of intermixing of a GaAs/AlGaAs quantum well structure through the irradiation of the interference fringes of high-power lasers at 266 and 532 nm. The period of surface grating ranged from 180 through 550 nm. It was found that the formation of silicon surface gratings was caused by the oxidation of silicon. The oxide of a larger volume formed the crests of the gratings. The oxygen in the oxidation process came primarily from water vapor instead of the oxygen molecules in the air. Meanwhile, the oxide showed the possibility of oxygen deficiency. In the case of GaAs, the surface grating was formed through the decomposition of the compounds. After arsenic was evaporated, gallium was sputtered to form the crests of the gratings. The effects of surface electromagnetic wave on the formation of surface grating and the relaxation of thermal strains built during the material melting will also be discussed. Regarding the formation of intermixing grating, it was purposely designed that the quantum well layers of the sample were illuminated by a periodically distributed laser intensity so that the laser-induced quantum well intermixing effect became spatially periodical. After a rapid thermal annealing procedure, a grating-like band-gap shift was measured with a micro-photoluminescence setup. The period of such intermixing gratings can be in the sub-micron range. The model of the inter-diffusion of aluminum and gallium atoms between the wells and barriers will be discussed for explaining the observed intermixing effects.

16:30
ThL5

COHERENT INTERACTIONS IN THREE-, TWO-, AND ZERO-DIMENSIONAL CdSe STRUCTURES STUDIED BY QUANTUM BEAT SPECTROSCOPY

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For many years, coherent spectroscopy in wide-gap semiconductor structures was limited to picosecond pulses due to the lack of spectrally tunable femtosecond lasers which cover the visible and ultraviolet spectral range. Using an amplified Ti:Sa laser combined by an optical parametric oscillator, 80 fs pulses tunable between 500 nm (2.48 eV) and 650 nm (1.9 eV) have been generated and applied to CdSe structures. Since the experimental setup provides pulses of an spectral width of ~25 meV, only such elementary excitations can be excited simultaneously which match that energy range. In bulk CdSe, the characteristic energies are 25 meV for the LO-Phonon energy, 25 meV for the A-B splitting, 15 meV for the exciton binding energy, and 5 meV for the biexciton binding energy. With increasing quantum confinement the energies of the excitonic states change, whereas the LO-phonon energy is only sligthly influenced by the confinement. By varying gradually the dimension of the semiconductor material from bulk CdSe via CdSe/ZnSe quantum wells to CdSe quantum dots, we are able to detect the dominant coherent interaction process for each dimensionality. The new features we have found are the following: In bulk CdSe we extract the quantum beat signal between the ground state 1s-exciton and the 2s-exciton. Furthermore, a strong FWM-signal is found for simultaneous excitation of exciton and continuum states. In quantum wells the polarisation dependence of the quantum beats indicates the presence of biexcitons. From the spectrally resolved four wave-mixing signal a biexciton binding energy of 20 meV is obtained corresponding to an enhancement by a factor of 4 with respect to the bulk. In quantum dots the coherent interaction is dominated by coupling to optical and acoustic phonons and quantum beats oscillating with the LO-phonon frequency are observed.

14:30-16:45 **BEIGE HALL**
ThM - Interference Phenomena in Atomic Systems I
Presider *A.V. Andreev, M.V.Lomonosov Moscow State Univ., Russia*

14:30
ThM1
(Keynote)

Paper is not available

15:15
ThM2
(Invited)

Paper is not available

15:45
ThM3
(Invited)

Paper is not available

16:15
ThM4

Paper is not available

16:30
ThM5

SUPER-RADIANT EMISSION WITHOUT INVERSION OF AN ENSEMBLE OF THREE-LEVEL ATOMS

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Originally, the theory of superradiance (SR) as a collective spontaneous emission was developed by Dicke [1] for a system made up of two-level atoms. It is well-known that one of the necessary conditions for this effect to be realized is existence of population inversion between levels involved in the emission process.

In last decade, the problem of amplification without inversion (AWI) is widely discussed [2,3]. Such a possibility appears if one includes into consideration a third level, for instance, close to the ground one (Λ-scheme), and prepares atoms in a certain coherent superposition of the bottom states, not coupled to the excited state. Then, another independent coherent combination turns out to be empty and, thus, one may obtain inversion between the operating states with no total inversion in the transition. As a result, a resonant pulse propagating through the medium prepared in such a way will be amplified.

The main goal of this contribution is to extend the concept of AWI to the SR emission and to show that the *super-radiant emission without inversion* (SREWI) can also be observed if one prepares atoms initially in a coherent superposition of the lower states. We discuss the effect of splitting of the lower atomic levels on the SREWI as well as how to create the low-frequency coherence necessary for the SRWI. In particular, it can be done by a low-frequency $\pi/2$-pulse of a duration T_P less than the SR emission delay time T_D. Normally, the latter is two orders of magnitude less than the duration of a single lobe of SR pulse. The SR emission in gases has sub-nanosecond time scale [4]. Then, to create a low-frequency coherence one should deal with a sub-microsecond low-frequency pulse.

[1]R.H.Dicke, Phys. Rev. **93** (1954) 99.
[2]O.A.Kocharovskaya, Ya.I.Khanin, Pis'ma Zh. Eksp. Teor. Fiz., **48** (1988) 581 [Engl. transl.: Sov. Phys. JETP Lett., **48** (1988) 630].
[3]S.E.Harris, Phys. Rev. Lett. **62** (1989) 1033.
[4]M.G.Benedict, A.M.Ermolaev, V.A.Malyshev, I.V.Sokolov and E.D.Trifonov, *Superradiance: Multiatomic Coherent Emission* (Bristol: Institute of Physics Publishing, 1996).

14:30-16:45 **PRESIDENT'S HALL**	**14:30-16:45** **BLUE HALL**
ThN - Postdeadline Papers I	**ThO - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics V**
Presider *I.G. Zubarev, Lebedev Physical Inst., Russia*	**Presider** *P.B. Corkum, National Research Council, Canada*
	14:30 **ThO1** **(Invited)**
	Paper is not available

15:00
ThO2
(Invited)

Nonlinear Optics in the Relativistic Regime

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At laser intensities exceeding 10^{18} W/cm^2, laser wakefields propagate with the laser pulse at at nearly the speed of light, which can trap and accelerate electrons. We show that the field gradient of such a plasma wave exceeds that of an RF linac by four orders of magnitude ($E \geq 200$ GV/m) and accelerates a picosecond bunch of electrons with over 1-nC of charge per bunch in a low-emittance beam (1 mm-mrad) [1]. We also demonstrate electron acceleration over distances exceeding the Rayleigh range, which currently limits the acceleration length of laser-plasma accelerators.

At high-laser power, the index of refraction of a Gaussian beam in a plasma varies significantly with the radius (since the plasma frequency varies with the relativistic mass factor of the oscillating electrons). Under these conditions, the plasma acts like a positive lens and focuses the beam (relativistic self-focusing). When this effect balances diffraction, relativistically self-guiding occurs, which is found to increase the laser propagation distance (by a factor of four), decrease the electron beam divergence (by a factor of two), and increase the energy of the accelerated electrons [2]. We have shown theoretically that the electron bunch duration can be reduced to as short as 1 fs [3].

Due to the enormous (Gbar) pressure exerted radially by the self-focussed laser pulse on the plasma, a hollow density cavity is observed—by means of time-resolved interferometry—to form in the wake of the laser pulse along the laser axis. This density channel is shown to act as a waveguide, capable of guiding a second collinear intense laser pulse also well beyond the Rayleigh range [4].

References

[1] D. Umstadter, S.-Y. Chen, A. Maksimchuk, G. Mourou and R. Wagner, *Science* **273**, 472 (1996).

[2] R. Wagner, S.-Y. Chen, A. Maksimchuk and D. Umstadter *Phys. Rev. Lett.* **78**, 3125 (1997).

[3] D. Umstadter, J. K. Kim, and E. Dodd, *Phys. Rev. Lett.* **76**, 2073 (1996).

[4] G. S. Sarkisov, V. Yu. Bychenkov, T. Tikhonchuk, A. Maksimchuk, S. Y. Chen, R. Wagner, G. Mourou and D. Umstadter, *Pis'ma Zh. Eksp. Teor. Fiz.* **66** *828 (1997)*.

15:30
ThO3

Nonlinear Optics with Super-Intense Few-Optical-Cycle Pulses

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Recent progress in developing techniques for generation and compression of ultrashort laser pulses has resulted in mastering the range of duration shorter than 5 fs. The use of broad-band laser crystals and optical elements with programmable dispersion, from the one side, and application of new ideas of nonlinear pulse spectrum manipulation, from the other side, have provided the optical community with a remarkable instrument, a source of coherent optical radiation with the pulse duration comparable with a single period of electromagnetic field. It has turned out that the technological and experimental progress in this area has to some degree left behind the theoretical comprehension of what may happen in nonlinear interactions of such short light bursts with matter. Most of the concepts of ultrashort pulse interactions rely on the validity of slowly varying field amplitude approximations, which in general is obviously not the case for few or single optical cycle pulses. In this report we make an attempt to put forward and analyze several problems that will arise in investigation of few-optical-cycle pulses propagation in ionized media. Our main goal is to draw the attention to the specificity of ionization nonlinear wave processes and outline new physical effect rather than to give a general approach for description phenomena beyond the slowly varying amplitude approximation. We consider a model for the optical pulse and plasma response based on the real electric field representation and the quantum mechanical description of electron dynamics in the ionization process. In the frame of this model we study the nonlinear atom response to short pulses, that can be dependent on the absolute phase of the optical field. A variety of interaction scenarios
relative to the waveform of the driving pulse will be presented. Among the discussed effects, the enhancement or prohibition of short wavelength emission by atoms, attosecond XUV continuum production, induced ionization scattering and optical pulse shortening to a single-optical-cycle burst are of particular interest.

We will demonstrate when and how the application of few-optical-cycle pulses can advance the process of XUV production at plasma ionization. In general, the sharper is the leading front of the driving pulse and the higher is the energy a detached electron can acquire outside the parent ion before the return collision, the shorter is the wavelength of bremsstrahlung photons. However, the integral bremsstrahlung efficiency depends on the dispersive spreading of electron wavepacket as a whole and its deviation due to the Lorentz force. The combination of the above factors put the limit for the energy of emitted short-wave length radiation, in particular, in the water window band.The most efficient XUV photon burst is produced by the plasma in the form of the of attosecond continuum that is quite sensitive to the phase matching conditions. That is why we will pay a special attention to analyze the limiting values of the frequency conversion efficiency and XUV pulse duration, which are due to plasma propagation effects.Finally, we discuss collective nonlinear ionization phenomena that can strongly affect the spatial and temporal properties of few-optical-cycle pulses. Among them, he effects of leaking mode self-channeling at saturable ionization, induced ionization scattering and pulse shortening to a single-optical-cycle burst are of particular interest.

15:45
ThO4
(Invited)

HIGH HARMONIC GENERATION IN COUNTER-PROPAGATING LIGHT

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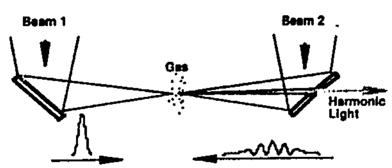
High harmonics produced in gases have become an attractive source for coherent vacuum ultraviolet radiation. In most cases, however, the generated harmonics (in particular the highest orders) have so little energy per pulse as to make them difficult to register, and this limits the prospects of their usefulness. The efficiency of converting laser light into high-order harmonics is seriously limited by phase matching (e.g., geometrical phase mismatches, refractive index mismatches, intrinsic phase mismatches arising from intensity gradients). The phase mismatches cause strong cancellations between harmonic light emerging from different locations in the laser focus. The limitations are so severe that typical optimal experimental conditions might appropriately be called phase mismatch minimization rather than phase-matching.

We present an approach which uses counter propagating light to disrupt harmonic production in specific regions of the laser focus in order to achieve quasi phase matching. Analysis shows that even relatively weak counter-propagating light can substantially suppress harmonic production via microscopic phase mismatches. Quasi phase matching over the focal volume is achieved using multiple counter-propagating light pulses which collide with the main pulse. The timing and durations of these counter-propagating pulses are chosen appropriately to frustrate harmonic production in selected zones with undesirable harmonic phase. The remaining regions constructively interfere, and analysis suggests that harmonic production can be boosted by as much as three orders of magnitude, depending on the specifics of the counter propagating light. We report on preliminary experiments which explore this technique.



Schematic of the experimental setup which uses a mirror with a hole in it to introduce the counter-propagating light while allowing the harmonics to be observed.

16:15
ThO5

HIGH-ORDER HARMONIC GENERATION AND ATTOSECOND SOFT X-RAY PULSES

V.T.Platonenko
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Obtaining of attosecond soft X-ray pulses by generation of high-order harmonics of laser light in a thin gas layer is under consideration. The theoretical model looks as following. Neglecting dispersion of the medium we represent the generated field as

$$E_1(R,t) = -\frac{1}{c^2}\int \frac{1}{R-r}\frac{\partial}{\partial t} j(r, t - \frac{R-r}{c}) d^3r \qquad (1)$$

where j is the current induced by the laser field E_0 only. The laser frequency ω_1 and low-order harmonics mainly deposit in E_1. They can be filtered by transformation

$$\tilde{E} = \iint f(\Omega)\exp[-i\Omega(t-t')]E_1(t')dt'd\Omega \qquad (2)$$

where $f(\Omega)$ is filtering function for example $f(\Omega) = \Theta(|\Omega| - \omega_f)$. To find atomic response we use the model of a single electron atom. The expression was obtained [1]

$$\partial j/\partial t = -(Ne^2/m\hbar^2)\int_0^{\infty} d\tau \int d^3p \exp[-\frac{i}{\hbar}\int_{t-\tau}^{t}(E_p + I)dt']p\,|\langle\varphi_p|V|\varphi_0\rangle|^2 + c.c. \qquad (3)$$

where $E_p = (p+eA/c)^2/2m$, φ_p - momentum eigen state, φ_0 - initial state of an atom, I- ionization potential. We suppose also that $|\langle\varphi_p|V|\varphi_0\rangle|^2 \sim \exp(-\mathrm{const}\cdot p^2)$. It gives possibility to integrate in (3) over momentum analytically. The integration over time τ and the integration in (1) and in (2) are fulfilled numerically. The integral (1) can be reduced to two-dimensional if one calculates the field at the axis of the beam and to one-dimensional if in addition the gas layer is supposed thin enough.

In the most general case the exiting field E_0 is synthesized as the superposition $E_0 = \int E_\omega \exp(-i\omega t)d\omega$, where E_ω is the field of gaussian beam with the waist diameter proportional to ω^{-1}. In case of mono- or bichromatic field E_0 the spectral representation is used in the analysis and calculations.

Close to generating layer (where plane wave approximation holds) the field (2) looks (under $\omega_f \approx 7\omega_1$) as a continues wave with strongly modulated frequency. If the filtering function in (2) extract some spectral interval (five – ten harmonics) a train of short (attosecond) pulses can be obtained. It occurs that in far zone diffraction provides spectral filtering [1]. Low harmonics strongly diverge due to large wave lengths; very high harmonics strongly diverge because they are generated only near the axis of the laser beam. The harmonics with intermediate numbers mainly survive and form attosecond pulses at the axis. Its structure changes with distance and depends on the waist diameter and wave front radius of laser beam. Pulse duration under 100as can be easily obtained in simulation.

To obtain a single pulse instead of the train the scheme with two crossed-polarized exiting waves with slightly differing frequency can be used [2] The problem can be solved also using very short laser pulses containing two-three periods of field. Results of simulation obtained using such pulses is being discussed.

1. V.Platonenko, V.Strelkov, Quant.El. 27, 779 (1997); ibid, Quant.El. to be published.
2. P.Corcum et al., Opt. Lett.19, 1870, (1994); P.Antoine et al., Phys Rev A, 56, 4960, (1997).

17:15-18:45 **GREEN HALL**

ThP - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies II

Presider *H. Coufal, IBM Almaden Research Lab, USA*

17:15
ThP1
(Invited)

Nonlinear Dynamics of Optically Pumped Photorefractives

H. John Caulfield, Nickolai Kukhtarev, and Marius Schamschula
Fisk University

Spatially uniform, temporally constant light incident on suitablephotorefractive material under suitable conditions and at appropriate *irradiance levels* can cause *self organization* and even chaos. This is a new set of phenomena brought together for the first time in this talk. With a single beam incident almost on axis, ths spatial pattern inside the crystal becomes irradince dependent. At low irradince levels, the crystal remains homogeneous, but above a threshold it self organizes into a 3D pattern which in crossection is hexagonal. Above a higher threshold, the hexagons start to rotate. Add a second beam from the *other side of* the crystal and the *noise holograms formed* by each beam independently self organize into a new kind of hologram that could not be recorded directly. Add yet anorther beam, and the temporal behavior of the beams undergoes totally unexpected regular behavior for a while then wanders in to chaos. These phenomena will be discussed and some preliminary thoughts on their potential applications will be offered, This is a work in progress seeking suggestions and additions from the listeners.

17:45
ThP2
(Invited)

PROPAGATION AND INTERACTION OF WAVES IN PERIODIC MEDIUM WITH SPACE-MODULATED COUPLING COEFFICIENT: APPLICATION TO OPTICAL FILTERING

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Although submicron harmonic Bragg gratings with fixed period and amplitude are now widely and successfully used in optical communication networks for filtering and wavelength division multiplexing, the future progress of optoelectronics is connected mainly with utilization of nonharmonic Bragg gratings, i.e. gratings with space-modulated amplitude, period or phase, since they have many advantages in comparison with conventional harmonic gratings.

In this report we investigate theoretically the processes of propagation, diffraction and interaction of monochromatic electromagnetic waves and pulses in periodic media with nonharmonic Bragg gratings, possessing space-modulated coupling coefficient and phase shifts. The analysis is based on coupled-mode theory and spectral approach.

It is shown that by using nonharmonic Bragg gratings it is possible to improve considerably the transmission characteristics of optical filters - demultiplexers: in particular one can design the narrowband demultiplexers with quasirectangular transmission window or to design the narrowband optical comb filters.

The peculiarities of transmission of regular and frequency-modulated picosecond laser pulses through nonharmonic Bragg gratings with phase shifts are investigated.

18:15
ThP3
(Invited)

INTELLIGENT MULTI-AGENT SYSTEM FOR INFORMATION PROCESSING

Dr. Jagdish Chandra
Deputy Director, Information Science and Technology Directorate/
Director of Atmospheric Research

Information/intelligent systems technologies are having revolutionary impact on a variety of fields ranging from information processing and digital communication for national security to manufacturing and industrial processes, and consumer needs in service industries. Impact of these technologies on education, training and health delivery systems is equally promising and spectacular. Recent advances in sensor technology, optical technology, computational platforms and knowledge-based systems has provided a major impetus to the advances in information/intelligent systems technologies. The conception, design, development and evaluation of such information/intelligent systems require research and development activities from multi-disciplinary groups. This talk will outline some emergingtechnical challenges in this area.

17:15-18:30 **RED HALL**
ThQ - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures VI
Presider *V.B. Smrimov, St. Petersburg State Univ., Russia*

17:15
ThQ1
(Invited)

SOLID STATE MATERIALS FOR RAMAN LASERS

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Stimulated Raman Scattering (SRS) in solid state materials is a new extensively growing area in laser physics. SRS allows to change laser radiation frequency with the certain energy shift that is determined by the crystal structure of Raman material. The advantage of solid state Raman material is their high concentration of Raman active centers and their favorable thermal and mechanical properties. There is a limited number of solids which have been identified to possess the narrow, isolated and intense Raman active vibronic modes which are necessary for efficient SRS scattering. Intense modes in solids can be attributed to internal symmetrical vibrations within molecular ionic complexes, such as $[CO_3]$, $[NO_3]$, $[SO_4]$, $[WO_4]$, $[MoO_4]$ and other. In spite of a large number of solids which exhibit SRS properties, nitrates of alkaline and alkali-halide metals, tungstates and molybdates attract attention as the most promising class of Raman laser media [1].

In this report we present the results of comparative spontaneous Raman spectroscopy of SRS-active modes in more than 20 perspective crystalline materials: nitrates, carbonates, tungstates, molybdates, niobates, phosphates are presented. Frequency shift from 200 to 1800 cm^{-1}, linewidth from 0.3 to 30 cm^{-1}, peak Raman gain coefficient from 1 to 11 cm/GW were measured in different materials. These data are important to characterize Raman properties of material for nano- and picosecond oscillations.

[1]. T. T. Basiev, A. A. Sobol, P. G. Zverev, Yu. K. Voron'ko, R. C. Powell, in Advanced Solid State Laser Technical Digest, (OSA Washington D.C. 1998) pp. 24-25.

17:45
ThQ2
(Invited)

SELFORGANIZATION OF 3D DEFECT-DEFORMATIONAL STRUCTURES AND THRESHOLD CHANGE OF OPTICAL PROPERTIES OF SOLIDS

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The theory of selforganization of 3D nanometer defect-deformational (DD)-structures in cubic crystals, subjected to action of external particle and laser beams is developed. It is shown that upon exceeding a critical concentration of point defects (vacancies and interstitials), pumped into a solid by external energy beam, the spatially uniform distribution of defects, interacting with each other through the deformation (strain) field, becomes unstable and DD-system makes a transition to a spatially nonuniform stable state, in which defects form localized or periodic piles up, captured in selfconsistent strain wells (nanometer DD-clusters and superlattices).

In treating the DD-instability a set of initial DD-equations is reduced to a closed nonlinear equation for selfconsistent strain. The exact stationary solution of this equation is obtained that gives the quantitative description of a hierarchy of processes of formation of steady state nanometer DD-clusters and superlattices occurring at different values of control parameters (defect concentration or temperature) [1,2]. The spatial-temporal dynamics of DD-structure formation is described quantitatively, the times of formation, periods and spatial distribution of defect concentration and strain in DD-structures are determined. The theoretical predictions are tested by comparison with experimental data on nanometer defect superlattices, formed in metals and dielectrics upon particle beam irradiation.

It shown that the spontaneous formation of nanometer DD-clusters and superlattices is accompanied by threshold change of optical properties of the host crystal. As examples the giant increase of optical nonlinearities at surfaces below the melting point, appearance of dipole quadratic nonlinearities in centrosymmetric semiconductors and change of electronic optical spectra are considered.

References:

1. V.I.Emel'yanov, Laser Physics, v.6, No.2, p.423, 1996.
2. V.I.Emel'yanov, I.M.Panin, Solid State Physics, v. 39, No.11, p. 2029, 1997.

18:15
ThQ3
(Invited)

A New Polymer Material For Optical Switching

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Summary

Three requirements satisfied for developing polymer optical switching material have been demonstrated according to theoretical and experimental researches, the number of double bonds of the material being around 7, non-degenerate ground state of the material and the high probability of charge transfer states. The push-pull azobenzene compounds, P-nitrophenylazo-N,N-dimethyl-phenylamine (NPADMPA) and P-nitrophenylazo-N-methyl-phenylamine(NPAMPA) have been synthesized for the device of optical switching. The microscopic nonlinearities of those samples are calculated with the semi-empirical methods,which use a combination of approximations and experimental data to simplify the mathematical problem. The 3rd order nonlinear susceptibility and the response time of the materials have been measured with the forward wave degenerate four wave mixing and Z-scan technique,which result in the expected high value reaching to 1.5×10^{-9} esu and 12 ps, respectively,and agreeing well with the theoretical values. The materials figures of merit are also obtained, which are 11, related to the 3rd order nonlinear susceptibility and 0.3, related to the two-photon absorption coefficient. The optical bistable behavior of a planar quasi-waveguide interferometer made with the sample film also shows that the samples feature excellent abilities to be used in the optical switching.

References:

1. M.Amano et al., Chem. Phys. Lett.,170,515,1990
2. D.J.McGraw et al., Appl. Phys. Lett., 54,1713,1989
3. M.Sheik Bahae et al., IEEE.QE. 6(4), 760,1990
4. A.Samoc et al., Opt. Lett., 20(11),1241,1995
5. Paras N. Prasad, Introduction to Nonlinear Optical Effects in Molecules and Polymers, John Wiley & Sons, 1991
6. A.A.Hasanein et al., Computational Methods in Quantum Chemistry, World Scientific Publishing, Co, 1996
7. M.Blanchard-Desce et al., JOSA, B15, 302, 1998
8. A.W.Harper et al., JOSA, B15, 329, 1998

17:15-18:45 **BEIGE HALL**
ThR- Interference Phenomena in Atomic Systems II
Presider *O.A. Kocharovskaya, Inst. of Applied Physics, Russia*

17:15
ThR1
(Invited)

A Quantum Trajectory Treatment of Gain Without Inversion in a Resonant V-Type Medium

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Proposals for amplification and lasing without inversion have stimulated discussion about the physical mechanism of the amplification. It is clear that coherence plays a key role, and the usual explanations are given in terms of quantum interference between transition pathways in the atom. For some amplification schemes the explanations are agreed upon; but for others, lingering questions remain—about ambiguities in the choice of basis states, and regarding the arbitrariness involved in attaching a physical interpretation to the value of a steady-state density matrix element when there is no clear specification of an individual system evolution, an evolution distinct from the ensemble average evolution that the density matrix obeys. Perturbation theory gives some sense of an individual system dynamic. But it is not entirely satisfactory, since perturbative methods presuppose a decomposition of the dynamics into an assumed set of transitions between certain initial and final states. This is fine if these states are clear from the experimental design. But if they are not, as in an ongoing photon scattering experiment with strong laser fields, it is the theory that must determine the appropriate initial and final states; it must also determine the frequencies at which these states are "prepared."

In this paper [1] quantum trajectory theory is used to analyze the gain mechanism underlying lasing without inversion in a resonant V-type atomic medium [2]. The advantage of the approach is that it separates the perturbative dynamics associated with photon scattering—realized in the theory by quantum jumps—from the nonperturbative dynamics driven by coherent laser fields and described in the theory by a Schrödinger-like evolution. Through the combination of the two, a well-defined stochastic, pure-state evolution for the atom is set up, generalizing the familiar Einstein stochastic process (spontaneous emission, stimulated emission and absorption) to a situation involving coherent excitation. Two explanations of the gain mechanism are developed. One based on the electromagnetic waves radiated by a modulated atomic dipole, and the other based on the exchange of light particles, as defined through observable signatures in the photon scattering sequences.

[1] H. J. Carmichael, Phys. Rev. A **56**, 5065 (1997)
[2] A. S. Zibrov, M. D. Lukin, D. E. Nikonov, L. Hollberg, M. O. Scully, V. L. Velichansky, and H. G. Robinson, Phys. Rev. Lett. **75**, 1499 (1995)

17:45
ThR2
(Invited)

COHERENT CONTROL OF NONLINEAR OPTICAL PHENOMENA

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The coherent control of nonlinear optical phenomena is fast turning into a major subfield of optics since the early theoretical proposals of Tewari and Agarwal [Phys. Rev. Lett. **56**, 1811 (1986)] and of Harris et al [Phys. Rev. Lett. **64**, 1107 (1990)]. Here we will review some of our recent work on two-photon absorption. We describe how the interference minimum could be controlled by changing the intensity and frequency of the control laser. We will show how a similar scheme enables one to enhance efficiency of two-photon absorption.

Our work on nonlinear mixing utilize the scheme proposed by Jain et al [Phys. Rev. Lett. **77**, 4326 (1996)]. We present a non-perturbative approach to study the generation of nonlinear signals in a coherently prepared medium. Specifically, we consider the process $\omega_1 - \omega_2 + (\omega_2 + \Omega)$, in a system prepared in a coherent population trapping state. We calculate enhancement factors of the order of 10^2 in the generated signal, under a variety of conditions. Our approach also enables us to study other related issues. We will show the existence of pulse matching at higher probe powers.

Finally, we will present the results on the coherent control of pulse propagation. We will show the possibility of optical pulse control and shaping in coherently driven media [Vemuri et al, Phys. Rev. Lett. **79**, 3889 (1997)].

18:15
ThR3

Atomic coherence effects in nonlinear optics and laser spectroscopy

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In conventional methods of resonant spectroscopy, optically thin ensembles of atoms or molecules are probed with lasers of limited intensity. Low intensities are used in order to avoid power broadening and frequency shifts. At the same time, the necessity of low-intensity light fields often results in an unfavorably low signal-to-noise ratio.

In the present paper we study experimentally and describe theoretically the spectroscopic properties of dense ensembles of atoms coherently prepared and probed by strong optical fields. Results of several different experiments involving nonlinear interaction in a coherent media will be reported. In particular, we observe and discuss the narrowing of power-broadened dark resonances in a dense media. When the atomic density becomes sufficiently large, we observe novel, narrow structures superimposed on the electromagnetically induced transparency (EIT) line. We find that these resonances are due to interference induced by a new field component arising from resonantly enhanced coherent Raman scattering. We show that, in contrast to simple transmission measurements, the characteristics of these novel spectral features are determined by the dispersive properties of the dense phase-coherent medium. In particular, their width can be orders of magnitude smaller than the usual power broadened limit and than the width of transmission EIT line. That is, power broadening can be compensated to a large extent.

We will also present a different approach to high-resolution spectroscopy in coherent media. It is based on an efficient process of mirrorless parametric oscillation in Raman-like, near-resonant systems driven by counter-propagating fields.

Our results suggest that a new regime of nonlinear two-photon spectroscopy is feasible, in which high spectroscopic resolution can be achieved with higher intensities and therefore with lower noise than in conventional methods. The main limitations of such techniques will be discussed.

18:30
ThR4

QUANTUM JUMP APPROACH TO INVERSIONLESS AMPLIFICATION IN THREE-LEVEL SYSTEMS: MONTE CARLO AND STATISTICAL ANALYSES

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We investigate amplification without population inversion (AWI) in different three-level systems driven by an on-resonance coherent field by using the Monte Carlo Wave Function (MCWF) and statistical quantum-jump (SQJ) techniques [1-3]. On one hand, we find that AWI at the wings of the resonance region is due to a fundamental asymmetry between one-photon stimulated emission and absorption processes in contrast with AWI at line center which arises from the contribution of two-photon gain processes. The first case corresponds to AWI in closed cascade three-level systems while the second one corresponds to closed V-type and Λ-type three-level systems. In addition, we obtain the respective contributions of one-photon and two-photon processes for all three-level schemes under investigation as a function of population decay and incoherent pumping rates.

On the other hand, we present a novel method to introduce dephasing processes in the MCWF formalism and demonstrate its equivalence with the standard density matrix approach. We compare our procedure with the one proposed in [2] to simulate dephasing processes showing two main advantages: (i) it is possible to associate dephasing processes with exchange of quanta since the initial state after a dephasing process collapses the wave-function in a well defined energy eigenstate, and (ii) quantum-jumps associated to dephasing processes collapse to a finite number of states instead of the infinite number in the standard case [2]. Our procedure allows thus to use the statistical tools developed in [3] to characterize the stochastic sequence of coherent evolution periods plus quantum jumps. We apply this procedure to study analytically and numerically the role of dephasing processes such as elastic collisions in AWI. In all three-level systems under investigation, we find that the main role of elastic collisions is to increase the incoherent pumping rate (threshold) above which AWI is reached.

[1] J. Dalibard, Y. Castin, and K. Mølmer, Phys. Rev. Lett. **68**, 580 (1992).

[2] K. Mølmer, Y. Castin, and J. Dalibard, J. Opt. Soc. Am. B **10**, 524 (1993).

[3] C. Cohen-Tannoudji, B. Zambón, and E. Arimondo, J. Opt. Soc. Am. B **10**, 2107 (1993) ; H. J. Carmichael , Phys. Rev. A **56**, 5065 (1997).

17:15-18:45 **PRESIDENT'S HALL**
ThS - Postdeadline Papers II
Presider *A.S. Chirkin, M.V.Lomonosov Moscow State Univ., Russia*

17:15-18:15 **BLUE HALL**
ThT - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics VI
Presider *V.T. Platonenko, M.V.Lomonosov Moscow State Univ., Russia*

17:15
ThT1
(Invited)

Paper has been withdrawn

17:45
ThT2

SCATTERING OF RELATIVISTICALLY INTENSE LASER PULSES IN COLD UNDERDENSE PLASMAS

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Summary

We present the linear instability analysis for the propagation of plane wave circularly polarized relativistically intense laser pulses in cold underdense plasmas. The above instability results from the interplay of the following phenomena: laser radiation Raman scattering by the plasmons it excites, the fluid dynamics analog of Compton scattering due to the electron response, excitation of harmonics explained by the effect of the relativistic and charge-displacement nonlinearities, harmonics decay causing the formation of electromagnetic waves and plasmons, interactions of electromagnetic waves in plasma, and the generation of a continuum of scattared radiation. The formalism used also describes the violation of the initial polarization of laser pulses in plasmas.

The propagating laser radiation is scattered both forward and backwards. The scattered light includes a set of harmonics which are scattered into imbedded spatial cones. Higher order harmonics are scattered into narrower cones.
In the slab geometry limit each of the incident radiation harmonics is comprised by the Stokes and anti-Stokes scattering components.

In the three-dimensional geometry the excitation of the Stokes component of Raman scattering at the laser pulse central frequency and the generation of a continuum of scattered radiation are the dominant phenomena. In the case of nonrelativistic intensities harmonics consist of both Stokes and anti-Stokes Raman scattering components. The latter results from the interaction of a higher order harmonics and the back-scattered Raman component. In the case of relativistically high intensities the components of harmonics merge into a single line.

18:00
ThT3

PROPAGATION PROPERTIES OF HARMONICS GENERATED IN GASES BY INTENSE LASER FIELDS

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In Refs.1 and 2, we presented a detailed analysis of dependences on experimental parameters of harmonic spectrum generated in gases by mixing of fundamental and second harmonics of a ps Nd-YAG laser. Particularly, conversion efficiency was investigated over two decades of gas density variation and for different configurations of *interaction volume with the aim of elucidating the role of phase-mismatch. Comparison* with spectra obtained by single frequency excitation showed that the wave-mixing scheme enhances the conversion efficiency by at least two orders of magnitudes and is quite insensitive to the phase mismatch. In addition, we observed a noticeable enhancement of harmonic conversion as the interaction length increases and when foci of pump fields are kept coincident by an achromatic lens [2].

In this work, we present a theoretical model describing the propagation properties of harmonics in one-color and/or two-color excitation based on a *ab initio* solution of propagation equation including radial profile of laser radiation. First, the model is applied to analyze the experimental results of Refs.1 and 2. Second, we compare conversion efficiency in picosecond and femtosecond regime and we discuss the conditions to achieve enhancement of harmonic spectrum. Finally, we show that dependences of conversion efficiency on experimental parameters, especially on gas density, are expected to be sensitive to laser pulse duration depending on the elementary mechanism of harmonic generation.

1) F.Giammanco, P.Ceccherini, C.Tagliavini, M.Malvezzi, P.Villoresi, G.Tondello-"Coherent VUV Radiation by Harmonic Conversion of Mixed Fields in Gases"- Laser Physics 7, 22 (1997)

2) F.Giammanco, P.Ceccherini-"Amplification of Harmonics Generated by Wave-Mixing"- to be published in Laser Physics (January-1998)

Poster Session

18:30-20:00 **GREEN HALL**

ThU - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies

ThU1 Characteristics of Reflection Type HOEs Measured Visually

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The method is to use a wide angle diverging laser beam instead of collimated beam for the visual inspection of both spectral and angular selectivities, and grating vector direction of HOE. When a highly diverging laser beam is incident normal to the HOE, if the beam's diverging angle is more than the input beam incident angle satisfying Bragg condition, the intensity distribution of the beam transmitted through the reflection type HOE will contain dark rings resulted by diffractions corresponding to different conditions of the HOE recording. The size, shape, thickness and direction of deviation of the rings relative to the center of the beam contain informations about the spectral and angular selectivities, and grating vector direction of the HOE. These rings can be seen by our eyes and make it possible to estimate the HOE characteristics by these rings. Fig. 1 shows an intensity distribution of a highly diverged beam passed through the HOE and appeared in the focal plane of a wide angle lens which is located immediately behind the HOE. It clearly shows a dark ring. When the dark ring's characteristics are analyzed, they are closely matched with those predicted theoretically. For different wavelengths of input laser beam, the results are almost the same.

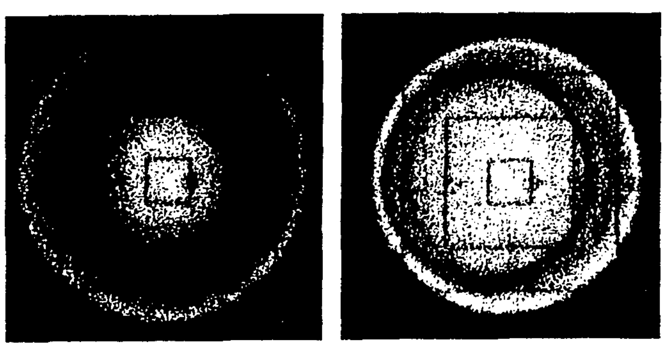

Fig. 1. The intensity distributions of the diverged beams passed through a HOE.

ThU2 Dispersion-managed soliton and a new generation of high-bit-rate fiber communication systems

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Optical soliton propagation in fiber lines is a fundamental theoretical problem that, on the other hand, has gr impact on the development of a new generation of communication lines. Recent fast progress in this field linking w the so-called dispersion management (intentional variation of a dispersion along the fiber link) leads to new interest applications of the soliton theory. In order to satisfy the demands of the future information transmission, which gr at an exponential rate, it is necessary to develop ultra-fast optical transmission lines, whose data transmission ra should eventually operate at few hundred gigabit per second regime. The possibility of the achieving of such a g was demonstrated in recent experiments [1-3]. Optical solitons are the real candidates to play a role of the carriers information in such a systems.

As a result of advent and development of optical amplifiers providing periodic amplification of lightwave signa fiber loss is no longer a major limitation in optical fiber communications. The performance of optical amplif systems is then limited by chromatic dispersion and nonlinearity. In the soliton transmission effects of nonlinear and chromatic dispersion are balanced making positive use of the nonlinearity. Detrimental effect of the chroma dispersion can be diminished by the dispersion compensation that is proving to be an efficient method to increa capacity of optical communication systems. Though dispersion management has been applied orginally in low-pow (linear) transmission systems, it has been found that this technique allows to enhance the soliton transmission [4. A transmission line constructed from alternated fibers with anomalous or normal dispersion has a low path-averag group-velocity dispersion (GVD), but a high local GVD, thereby suppressing the Gordon-Haus timing jitter a the four-wave mixing efficiency simultaneously. Soliton transmission allows to carry higher bit rate per channel comparison with non-soliton transmission. Enormously large fiber bandwidth can be additionally exploited by sendi carrier signals at different wavelenths. Wavelength-division multiplexing (WDM) transmission of dispersion-manag solitons is an attractive way to realize future ultra-high capacity optical communication systems [1-3]. Considera work has thus been motivated to study in details the dynamics of dispersion-managed soliton for different syst design and to optimize the dispersion management for such systems.

I overview recent progress in this field and present a theory [5,6] that describes all known features of dispersi managed soliton, such as enhanced power, chirping, quasi-self-similar structure of the pulse, suppressed interactio form deviating from sech-profile, oscillating tails and so on. Characterizing the pulse by a few relevant paramet one can determine the evolution of these parameters via ordinary differential equations. Theoretical predictions a confirmed by comprehensive numerical simulations and compared with experimental results. It is found dispersi management advantageous for massive multi-channel soliton transmission.

1. L.F.Mollenauer, P.V.Mamyshev and M.J.Neubelt, "Demonstration of soliton WDM transmission at up to 8 10*Gbit/s*, error-free over transoceanic distances", Post Deadline presentation, PD22-1, OFC'96, San Jose.
2. M. Nakazawa, K. Suzuki, H. Kubota, and E. Yamada, Electron. Lett. 32, 1686 (1996).
3. M. Suzuki, I. Morita, N. Edagawa, S. Yamamoto, H. Taga, and S. Akiba, Electron. Lett. 31, 2027 (1995).
4. V. A. Bogatyrjov, M. M. Bubnov, E. A. Dianov, and A. A. Sysoliatin, Pure and Appl. Optics 4, 345 (1995).
5. N. Smith, F. M. Knox, N. J. Doran, K. J. Blow and I. Bennion, Electron. Letters, 32, 55 (1996).
6. I. Gabitov, E. G. Shapiro, and S. K. Turitsyn, Opt. Commun., 134, 317 (1996); Phys. Rev. E, 55, 3624 (1997
7. S. K. Turitsyn, JETP Letters, 65(11) (1997) 845; E. Shapiro and S. K. Turitsyn, Opt. Lett. 22 (1997) 1541 Phys. Rev. E 56 (1997);

ThU3

Optical Kerr Effect in Photochromic Media

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Currently, much attention is focused on the investigation of the possibility of implementing nondestructive data reading with the use of fluorescence of photochromic molecules (e.g., see [1]). The main advantage of the fluorescence technique for reading the data stored in a photochromic medium is associated with a sufficiently high level of the readout signal, which can be used for luminescent imaging of the photocolored area. However, a fundamental drawback of the fluorescence method of data reading stems from the fact that radiation exciting fluorescence simultaneously partially erases the data stored in a sample through the reverse photoreaction of photochromic molecules.

The implementation of truly nondestructive reading in 3-D optical-memory devices may become possible with the use of coherent four-wave mixing [2]. In this paper, we investigate characteristics of optical Kerr effect in spiropyran solution (Fig. 1) and compare the possibilities of data-reading methods with the use of fluorescence and four-photon techniques. It is proposed to implement data reading in 3D optical-memory devices through the detection of the Kerr-effect-induced change in the polarization of the reading laser beam passing through a 3D optical-memory unit.

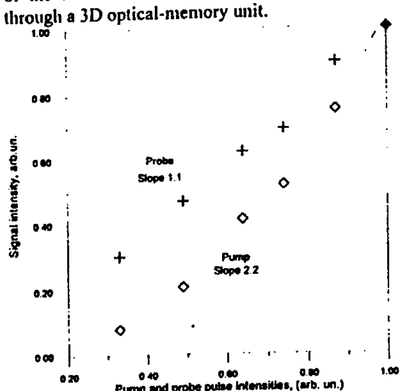

Fig. 1. Amplitude of the Kerr-effect readout signal as a function of the powers of the probing and pumping pulses.

The main advantages of data reading in three-dimensional optical-memory devices with the use of optical Kerr effect over the fluorescence method of data reading can be summarized as follows: (i) optical Kerr effect provides an opportunity to increase the locality of data reading in three-dimensional optical memory devices, and (ii) optical Kerr effect does not imply real population transfer in photochromic molecules, and, therefore, in contrast to the fluorescence technique, allows one to implement truly nondestructive data reading.

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References

1. S. Hunter, F. Kiamilev, S. Esener, D.A. Parthenopoulos, and P.M. Rentzepis, *Appl. Opt.*, 29, 2058 (1990); A.S. Dvornikov, I. Cokgor, F. McCormick, R. Piyaket, S. Esener, and P.M. Rentzepis, *Opt. Commun.*, 128, 205 (1996); M.M. Wang, S.C. Esener, F.B. McCormick, I. Cokgor, A.S. Dvornikov, and P.M. Rentzepis, *Opt. Lett.*, 22, 558 (1997); D.A. Akimov, A.B. Fedotov, N.I. Koroteev, S.A. Magnitskii, A.N. Naumov, D.A. Sidorov-Biryukov, and A.M. Zheltikov, *Jpn. J. Appl. Phys.*, 36, Part 1, No. 1B, 426 (1997).

2. D.A. Akimov, A.B. Fedotov, N.I. Koroteev, E. Levich, S.A. Magnitskii, A.N. Naumov, D.A. Sidorov-Biryukov, N.T. Sokolyuk, and A.M. Zheltikov, *Optical Memory and Neural Networks*, 6, No. 1, 31 (1997).

ThU4

PATTERN FORMATION IN ACTIVE OSCILLATORY MEDIA AND ITS RELATION TO ASSOCIATIVE MEMORY NETWORKS

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Associative memory based on coupled Ginzburg-Landau oscillators seems to be very promising in design of nonlinear optical neural network models. Theresults obtained earlier concerned the design of associative memory in oscillatory networks of Hopfield type. In particular, it was shown that homogeneous locally connected closed chains of oscillators are the principal building blocks for oscillatory networks with Hebbian matrices of connections. For small ($N \leq 6$) numbers N of oscillators in a chain, the strict results on memory structure were obtained. The recent results are related to the fact that 1D active oscillatory media are the continuous analog of homogeneously locally connected networks of oscillators. In our case these media are governed by the system of two reaction-diffusion equations with a single spatial variable. Using computer modelling, pattern formation in oscillatory media has been compared with the behaviour of the corresponding oscillatory chains. Locally connected oscillatory networks are valuable in the context of neurophysiology: 1D chains – in modelling of cortical oscillations whereas 2D – in modelling of receptive fields responsible for orientation. The simple single-oscillator model reproducing the main features of the known many-parametrical Wilson-Cowan oscillator has been suggested. The initial series of computer experiments on synchronization in closed and unclosed chains of oscillators has been carried out. In addition, it would be pointed out that structural rearrangements in 2D spin physical systems, demonstrating formation of topological defects, can also be simulated with the use of 2D locally connected oscillatory networks.

ThU5

NONLINEAR OPTICS AND FEMTOSECOND LASER INFORMATION THEORETICAL QUANTUM SPECTROSCOPIC DYNAMICS OF THE MOLECULAR BONDS

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SUMMARY:
RESONANTLY INTERACTING ULTRASHORT HIGH INTENSITY LASER PULSE SEQUENCES CORRESPONDING TO VIBRATIONAL FREQUENCIES OF CHEMICAL BONDS ARE USED TO INVESTIGATE THE INFORMATION CAPACITY OF A CHEMICAL BOND IN MOLECULES.BY COMBINING INFORMATION THEORY,STATISTICAL THERMODYNAMICS, AND QUANTUM MECHANICS IT IS POSSIBLE TO STUDY THE CODING AND DECODING MECHANISMS OF STORAGE AND TRANSFER OF INFORMATION AND ENEGRY IN MOLECULES.LIKE COMMUNICATION THEORY THE FEMTO AND SUBPICO SECOND SEQUENCE OF LASER PULSES BE MADE TO PROBE THE QUANTUM DYNAMIC VARIABLES INTRODUCED DUE TO RESONANCE ENHANCED INDUCED HIGHER ORDER NONLINEAR OPTICAL EFFECTS OF EXTERNAL FIELD PERTURBATIONS IF PULSEWIDTHS OF THIS IS SHORTER THAN RELAXATION TIMES,THE NONLINEAR RESPONSE OF ELECTRONS IN MOLECULES INTERACTING WITH LASER PULSES DESCRIBED BY A 3rd.RAND TENSOR OF GEOMETRICAL DERIVATIVES OF ELECTRIC POLARIZABILITY AND NUCLEAR HYPERSHIELDING ARE AT DISPLAY WHICH SET IN A LORENTZ FORCE DUE TO IR EXTERNAL FIELD AND NONLINEAR RESPONSE OF PERTURBED ELECTRONS.THE HYPERSHIELDING TENSOR DETERMINES THE INDUCED ELECTRIC DIPOLE MOMENT IN ELECTRON CLOUD AND NUCLEAR MOTION,DISPLACEMENT OF NUCLEI FROM EQUILIBRIUM COORDINATES,DEPENDENCE OF MOLECULAR GEOMETRY,CONTRIBUTIONS TO NUCLEAR VIBRATIONS,AND ELECTROMAGNETIC FIELDS SHIELDED BY MIXED QUAROPOLE POLARIZABILITY.
THE STORAGE AND TRANSFER OF INFORMATION LIES IN GEOMETRICAL DERIVATIVES OF POLARIZABILITIES AND HYPERPOLARIZABILITIES WHICH CONTROL THE TRANSLATIONAL,ROTATIONAL VARIANCEBY MEANS OF FORCE AND TORQUE SETTING ULTRASUBMICRO-MICRO QUANTUM MECHANICAL MOTORIZAION OF BONDS AS INTERNAL MOTIONS TO ENGINEER THE CODING-DECODING PROCESSES OF MANUFACTURING SPECIFICITIES TRANSFOREMING MOLECULAR SPECIES WITH NEWER BONDS.

ThU6

FUZZY AND MULTIPLE-VALUED OPTOELECTRONIC DATA PROCESING BASED ON MAXIMUM, MIMIMUM AND PARAMETRICAL LOGICAL GATES.

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The schemes and the optoelectronic hardware are discussed for data processing systems, based on the multiple-valued logic and the fuzzy logic. The combined use of the multiple-valued Allen-Givone algebra subsystem and the subsystem, realizing compositional fuzzy logical inference rule, is considered to unite them into one parallel data processing system. That gives the possibility to employ simultaneously the crisp (precise) and the fuzzy (approximate) depiction of features for a large number of input variables. Such an approach is intended for the description of complex systems for which formalized complete description is a bottleneck, but it is required for example to change a set of fuzzy " If...then... " rules depending on the input data. Multiple-valued and fuzzy logic operators are being realized in such a system as specialized optoelectronic gates MAXIMUM, MINIMUM, SUPREMUM, LITERAL and not calculated in the PC processor. Each of the sybsystems employs only from 3 up to 8 specialised gates and specialized units. The hardware realization of such a system for a large number of input and output variables can be used for an image processing, while a system with a limited number of variables can be applied for sensor data processing and action control. Besides original designes of optoelectronic MAXIMUM, MINIMUM logic gates, based on planar waveguide switches, optical frequency coding of logic values, modified scheme of vector-matrix multiplier, one can use optoelectronic parametrical T-operators of fuzzy logic, in which the result of logical operations can be regulated, depending on the value of the special parameter.

1.M.L.Arestova,A.Yu.Bykovsky.Quantum Electronics,v.25,N10,(1995),p.945-949.
2.M.L.Arestova,A.Yu.Bykovsky.Patent of Russia N2044338, State Registrated 20.09.95

ThU7

DYNAMICS OF LONG-WAVE SEMICONDUCTOR LASERS WITH PHASE-CONJUGATE FEEDBACK

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External cavity effects in semiconductor lasers have long been of interest. Although feedback from a conventional dielectric mirror has been well studied, phase-conjugate feedback (PCF) has been investigated within the last 7-8 years. The semiconductor lasers with PCF have demonstrated line width narrowing, frequency selection, frequency stability and coherence collapse. In general, the laser dynamics depends on the phase shift acquired in the external cavity. This dependence on the external phase shift can be eliminated if the feedback occurs from phase-conjugate mirror.

Effect of phase-conjugate feedback on dynamics of long-wave semiconductor laser has been investigated and modeled. Because of narrow-gap active layers long-wave lasers are very sensitive to nonlinear dependence of gain on carrier concentration, enhanced in comparison with AlGaAs lasers (~ 4 times more) gain compression factor, and reduced (by 2÷5) linewidth enhancement factor. Moreover, spontaneous recombination contribution into a laser mode and more intensive influence of nonradiative recombination (such as Auger one) on lasing regimes can sufficiently modify stability / instability conditions.

On the basis of numerical analysis of rate equations regions of steady-state lasing and bifurcation to Hopf-like and chaotic regimes have been investigated and determined. Difference of effects of phase-conjugate feedback on long-wave (1.3-1.5 μm) and ~ 0.7-0.8 μm laser dynamics is discussed.

ThU8

Coherent Optics Methods in the Systems Analyzing Images Passing Through Disturbing Media

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Recently in processing of optical signals, the new approach to solve the problem of eliminating the instrumental and transmission functions has appeared. It is related to simultaneous determination of characteristics of both the signal under consideration and the transmission function. In the paper, we consider the problem of determining the phase-amplitude characteristics of the two-dimensional optical signal forming the image as well as the two-dimensional complex transmission function that describes the disturbing of the signal while being transferred. The solution is based on measuring four independent two-dimensional intensity distributions obtained by certain additional spatial modulations, with output representation of the signal by its spectrum of the spatial frequencies. The additional modulations are introduced both for the tested signal itself and for the output signal (i.e. that with the transmission function involved). These additional modulations are designed to somehow transform the phase information into the amplitude one. The first intensity distribution is registered without additional modulations. The second and the third ones are obtained by just one of two modulations. The fourth distribution corresponds to the signal undergone the two additional modulations. The two-dimensional intensity distributions obtained allow one to perform calculations for the amplitude and the phase of the analyzed signal and for the transmission function. The visual results are obtained with using the linear amplitude modulation.

The paper is partially supported by the Russian Foundation for Basic Research, under Project 96-02-19107a and by the government program "Optics. Laser Physics".

ThU9

POLARIZATION MODE DISPERSION MEASUREMENTS ALONG OPTICAL FIBER.

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The fiber optic communication lines improvement is coming now to technical limit due to the polarization mode dispersion (PMD) in the single mode fibers. These fibers are always birefringent because of irregular anisotropy stresses arising during the fabrication, cabling and installation. A lot of methods have been proposed to measure the cumulative PMD in a fiber cable [1], but there is no information about the distribution and accumulating PMD along the real fiber line.

The most convenient method, which can visualize the polarization beating along a fiber is the polarization time domain reflectometry (POTDR). This method based on the polarization analysis of the backscattered waves, which time delays, contains the information about the scattering position in the fiber. POTDR have been proposed for the fiber optic sensors and give the possibility to measure the light ellipticity along the fiber. POTDR can measure the birefringence in special regular fibers easy, but the interpretation difficulties arises for real irregular fibers.

By the theoretical analysis we spread the application range of POTDR on irregular fibers. The analysis is based on the evolution of the polarization representation using Euler parameter. This way we can divide measurable and not measurable parameters and establish the correspondence between POTDR data and local fiber birefringence. Then we have checked our method on the computer model of the irregular fiber and find good precision of the local birefringence recovery. The first experimental verification of the method also have been made.

References:

[1] A. Galtarossa, "In-Field Comparision Among Polarization-Mode-Dispersion Measurement Technoques.", J. of Light. Tech., Vol. 14, 1, Jan. 1996.

ThU10

PHOTOPOLYMERS FOR HOLOGRAPHY:

INTERCONNECTION BETWEEN HOLOGRAPHIC CHARECTERISTICTS AND PARAMETERS OF PHYSICAL-CHAMICAL PROCESSES CAUSING RECORDING

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Among numerous photopolymer materials for volume holograms recording researched since 60's photopolymer compositions (PPC) with polymerization-diffusion mechanism of recording have offered the greatest promise. A subject of study of the present work is the PPC-488. It includes photopolymerizable compounds and the neutral component (NC). Holograms in it are formed during recording in result of polymerization and the spatial diffusion redistribution of monomer and NC.

The purpose of the recent work is the establishment of the interrelation between the holographic characteristics of PPC thermodynamic properties of composition and parameters of photophysical and photochemical processes causing formation of phase holograms. The following results were obtained.

Efficiency of holographic recording in such compositions and noise characteristics of holograms are determined by thermodynamic compatibility between the forming polymer and NC which characterized by the Huggins interaction parameter (χ) and the concentration of NC (C_{NC}) in mix. The decrease of compatibility gives rise to growth of recording efficiency but is attended with the increasing of the nose caused by the polymer heterogeneity. The regions of χ and C_{CN} values were determined which give the maximum efficiency of recording at minimum level of noise.

The kinetic of recording was investigated for PPS-488 and HRF-150-38 (Du Pont). It was shown that efficiency and recording rate are maximum when the kinetic of recording is determined by the kinetic of polymerization. In this case the rate of diffusion is much greater than the polymerization rate and does not limit the spatial segregation of components. Criterion of recording efficiency was offered $D_{ef} = D_o u_p / \Lambda^2 I^{1/2} > 1$, where $u_p = (1/k_g)(k_b/k_{in})$, D_o- the diffusion constant; k_g, k_b, k_{in}- parameters of growth and break of chain and initiation of polymerization; Λ, I - period and intensity of interference field. Conclusion was made that at $\Lambda < 0.3$ μ and $I < 14$ mW/cm^2 the kinetic of recording in such materials is defined by the kinetic parameters of polymerization process.

ThU11

Holographic Device for Addition and Subtraction of Fuzzy Numbers.

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Fuzzy Sets Theory (FST) is acknowledged as the theoretical approach to Artificial Intelligence building that is adequate to real world and brain. Theory of Fuzzy Numbers (FNs) allows Fuzzy Systems to be studied by numerical methods. Definition of FNs as subsets leads to the conditions for hardware that cannot be satisfied by electronic technique. Our approach is based on the analogies between optical phenomena and principles of FST. The idea of holographic processor for operations on FNs realization is developed in both theory and experiments.

To construct an algebra, conventional definition of FNs as the subsets, defined on the numerical axis, that are normal, convex, and unimodal, is used hereby. So, FNs by the images, satisfying the conditions, are optically represented. Operation of convolution, realized by the scheme of off-axial Fourier-holography, as an abstract addition is used. The result of convolution as a sum of reference and object images is treated. Repeating of the procedure constructs the semi-group of FNs. Delta-function, defined as a Fourier-transform of the reference beam, is the zero element for the monoid of FNs to be constructed. Operation of extended subtraction is realized by diffraction of the wave, corresponding to the Fourier-transform of minuend FN, on the inverse hologram of subtrahend FN.

Monoid of Gaussian FNs was constructed experimentally. To implement both addition and subtraction by one hologram the medium PFG-03m, having range of exposure curve so, that diffraction efficiency for the minus first diffraction order decreases whereas one for the plus first order increases was used. If images, used as FNs, have axial symmetry, those orders of diffraction are equivalent. So, both addition of FNs in the plus first diffraction order and subtraction of those FNs in the minus first diffraction order were implemented by one hologram.

ThU12

Ultimate speeds of ultrafast nonlinear soliton switching and logic gates for optical super computing

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Optical solitons have now developed to the point where they can be seriously considered for future applications of all-optical high-bit-rate communications, ultrafast switching and soliton logic for optical supercomputing. Our investigations covered new soliton solutions of nonlinear Maxwell's equations, which open possibilities for constructing nonlinear optic logical elements with speeds as high as 100 Tbit/s. Electronic logic and switching systems can operate at maximum speeds limited by 20–50 GHz due to transit, relaxation and thermal diffusion times [1,2]. The main idea is to overcome the electronic bottleneck using the terabit-rate optical soliton-dragging logic gates [3]. Soliton logic gates include soliton dragging, soliton trapping and billiard-ball soliton interaction gates. As was shown in previous works, soliton-dragging logic gates satisfy all requirements for a digital optical processor, including fan-out, cascadability and Boolean completeness. Previous results in the field were obtained on base of the so-called slowly varying approximation methods and therefore were principally limited by 10–100 Gigabits per second operating speeds. Future soliton logical systems are expected to process net data rates approaching 200 Tbit/s, that low-loss window between 1.3 and 1.6 mkm allows in pure optical glasses with bandwidth 40 THz. The primary goal of our report is to answer the key questions of nonlinear soliton logic devices; that is, what the ultimate speed of soliton switching elements that can be achieved, and how soliton logic and memory elements can be constructed in the 100 Tbit/s speed region? We have also modelled the new possibility of so-called spectral femtosecond soliton tunnelling and trapping [4] for solitons dragging and trapping logic gates construction.

Finally, as it follows from our simulations the nonlinear switching and storage regimes could be realized. And in the conclusion we note that today the most attractive medium for ultrafast soliton logic and soliton memory are optical glasses and optical telecommunications fibers.

References

1.D.A.B.Miller, R.A.Athale, SPIE, CR35, 68, 1990. 2.P.W.Smith, Bell System Tech. Jour., 61, 1975, 1982. 3.M.N.Islam, Ultrafast fiber switching devices and systems, Cambridge University Press,1992. 4.V.N.Serkin, V.A.Vysloukh and R.J.Taylor. Electron Letters, V.29, N1, p. 12-13, 1993.

ThU13

Laserlike effect in powders and a possibility of its use for information processing

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The existence of the laserlike effect in powdered luminophores was demonstrated first in 1986 [1]. Investigations of this effect [2-6] showed:
1. when the resonance pulsed pumping exceeds a threshold level the width of the emission line sharply narrows (to <0.1nm) and the emission kinetics becomes a series of pulses with minimum pulse duration ~300ps [2,6];
2. in powders with shapless particles emission takes place always in one narrow line at the centre of luminiscence band [2], but in the powders with more or less regularly shared particles emission can occur on several lines in the region of luminescence band [3];
3. in mixture of two powders with different frequencies of laser transition (FLT) emission takes place on intermediate frequency (when the difference between the FLT is very small) [4,5], or on two frequencies which don't coincide with the corresponding F LT (when the difference is not small) [6].

Using the contrast of speckle structure we evaluated the degree of coherence (DC) of laserlike radiation from powders. It appears that the DC is considerably lower than for usual lasers with mirrors, but it has a noticeable value. It was found that in some cases the DC is near to its value for a dye laser.

Investigation of the spatial characteristics of the spot of laserlike radiation from powders showed that minimum spot dimensions are 20-30μm (particles dimensions ~4-20μm).

A possibility of using the laserlike effect in powders for creation of cathode screens with narrowband (~0.1nm) and short (~1ns) luminescence is discussed. Preliminary experiments with powdered luminophores doped with neodymium and praseodymium were performed. As a more distant perspective a possibility of using this effect for creation of optical memory cells is also discussed.

References

1. V.M.Markushev, V.F.Zolin, Ch.M.Briskina, *Kvantovaya Electron. (Moscow)*, **13**, 427 (1986) [*Sov.J.Quantum Electron.* **16**, 281 (1986)]
2. V.M.Markushev, N.E.Ter-Gabrielyan, Ch.M.Briskina et al., *Kvantovaya Electron. (Moscow)*, **17**, 856 (1990) [*Sov.J.Quantum Electron.* **20**, 773 (1990)]
3. N.E.Ter-Gabrielyan, V.M.Markushev, V.R.Belan et al., *Kvantovaya Electron. (Moscow)*, **18**, 928 (1991) [*Sov.J.Quantum Electron.* **21**, 840 (1991)]
4. N.E.Ter-Gabrielyan, V.M.Markushev, V.R.Belan et al., *Kvantovaya Electron. (Moscow)*, **18**, 38 (1991) [*Sov.J.Quantum Electron.* **21**, 32 (1991]
5. Ch.M.Briskina, V.M.Markushev, N.E.Ter-Gabrielyan *Kvantovaya Electron. (Moscow)* **23**, 947 (1996) [*Quantum Electronics*, **26**, 923 (1996)]
6. M.A.Noginov, N.E.Noginova, H.J.Caulfield et al., *J.Opt.Soc.Am.B*, **13**, 2024 (1996)

ThU14

PHOTOCHROMIC ORGANIC COMPOUNDS WITH POLYFUNCTIONAL PROPERTIES

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As of now the photochromism, that is a reversible photoinduced color change of substances, becomes very important for investigations and application. This is due to advances in the development of photochromic polymeric sun protective glasses as well as to perspectives of using photochromic materials as light - sensitive recording media.

Future widening the application fields for photochromic systems depends on advances in the development of photochromic substances with a new properties. In this connection advances in the study of photochromic compounds and systems which manifest reversible photoinduced changes not only in absorption, but another properties as well (irradiation capability, refractive index, light scattering, nonlinear optical characteristics, etc.) are discussed. The synthesis and study of these polyfunctional organic photochromic compounds are a modern line of the development photochromic materials. They are candidates for modern optical information technologies and molecular photonics.

The achieved results expand the possibility for application of this materials even today. Two - photon photochromic polymeric media with photoinduced fluorescence are used for the development volume optical memory with superhigh information capacity. Photochromic materials possessing photorefraction are acceptable as recording media for holography. Photoinduced phenomena linked with changes of irradiation capability, refraction index, nonlinear optical characteristics, conductivity and electric potential during photochromic transformations open perspectives for the development of molecular photonics. In his connection of particular interest is multi - mode photoelectrochromic organic systems. Future trends are associated with the following developments of polyfunctional organic photochromic compounds.

ThU15

ACOUSTO-OPTICS IN INFORMATION TECHNOLOGIES

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Acousto-optical (AO) methods of laser beam control are widely used in contemporary systems of information record, store, retrieve, and display. Here, AO components must provide a random addressing mode (deflection) of the laser beam, its linear scanning, the amplitude and phase modulation for number of beams (by multi-frequency control), filtration of several lines of polychromate beam etc. Common requirements for these components are the high diffraction efficiency of light on acoustic waves and the high bandwith of control frequencies.

Our studies of anomaly light diffraction on one acoustic wave or on several ones in anisotropic medium have allowed a creation (basing on crystals of TeO_2) a series of anisotropy two-dimensional light deflectors (resolution 512 x 512 positions, control freguence bandwidth 50 MHz) and multi-beam light modulators (number of output beams is 32), spectral filters for a parallel modulation of lines of Ar-Kr laser (number of lines is 12, diffraction efficiency is 96%).

To significantly increase the frequency band, the diffraction efficiency, and the performance of both anisotropic and isotropic AO cells based on both shifted and longitudinal acoustical waves, the effective methods for the acoustic wave front control were developed. They have ensure a creation (basing on crystals of TeO_2) the anisotropic deflectors that have the frequency band up to 100 MHz and the diffraction efficiency over 80%, as well as the isotropic linear scanners that have the frequency band 100 MHz and 200 MHz, and efficiency 80% and 40%, receptively.

The AO components developed are used in the laser systems for 3D record/storage in volume media, for displaying 2D and 3D images in real time, for multi-channel image recording in the printing industry, for recording of a high-speed digital data flow onto optical disks and so on.

ThU16

HIGH SPEED 3-D RECORDING-READOUT OF THE INFORMATION IN THE VOLUME MEDIA WITH THE USAGE OF OPTICAL HETERODYNE AND MULTILEVEL PHASE DATA CODING (OPTICAL SYSTEM AND ITS COMPONENTS)

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The present paper discusses the method of multilayer optical recording of digital data in the volume medium, as a means of increasing of the recording density[1].

The method is based on the volume localization of the interference structure of "pit" at recording and heterodyne phase-sensitive selection of the structure at readout.

To increase the speed and the density of recording we offer to use a method of relative phase modulation in the written pit-grating.

Every data bit is recorded here on the carrier in the form of a volume interference micrograting having 2 - 3 fringes. and having a size of $1.1 \cdot 1.7 \cdot 7 \mu m^3$. Application of the heterodyne method for readout makes it possible to reconstruct the data encoded as phase of the interference grating and also decrease the influence of non-addressable information layers.

The substantial growth of speed (up to 256Mb/c) of recording-readout was obtained at the usage of the high-speed scanning of the laser beam on the radius of the disk. While the speed of driving of the medium was not rising. The description of the device and principle of operation of the scanner based on the travelling acoustooptical lens with accompaniment is given.

The optical scheme of the drive is given and acoustooptical elements, determining the structure of optical scheme are considered. The evaluation of speed and bit density is given.

1. I.B.Rudakov, I.Sh.Steinberg, Ju.A.Shepetkin,"Multilayer optical information recording," Optoelectronics, Instrumentation, and Data Processing, (Avtometrija) 1991, no 3, p. 76-80.

ThU17

PECULIARITIES OF OPTICAL FORMATION AND FILTERING THE IMAGES AND DIFFRACTION PATTERNS OF VOLUMETRIC OBJECTS APPLIED TO 3D MEASURING TECHNOLOGIES

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Progress in developing 3D measuring technologies for noncontact dimensional inspection depends to a great extent on the presence of constructive theory of formation images and Fraunhofer patterns of volumetric objects in passing light. Since the existing strict and approximate solutions for diffraction problem are extremely difficult for engineering applications, the author first suggested in [1] constructive method for evaluating Fraunhofer diffraction patterns of constant thickness with flat inner surfaces, which is simple, physically obvious and at the same time sufficiently strict. It is based on the model of equivalent diaphragms, located in space, that allows to apply the standard the Kirchhoff-Fresnel approximation for the calculation of Fraunhofer patterns.

Dependencies between the characteristic parameters of the diffraction patterns and geometric dimensions of 3D typical objects (optically thick edge, volumetric slit) are found. Suggested efficient algorithms allow by corresponding processing of diffraction pictures to determine transverse and longitudinal sizes of extended objects with the errors 0.1% and 1% accordingly.

Peculiarities of coherent optical processing of 3D objects are investigated in detail by the example of high-frequency filtering (contouring) of volumetric edges with perfectly absorbing and reflecting inner surfaces.

Results of the investigations showed a satisfactory agreement of the theoretical and experimental data. They are applied first of all for 3D optical sensing, Fourier optics of 3D objects, optical metrology, 3D microscopy.

REFERENCE

1. Yu. V. Chugui, B.E. Krivenkov. Fraunhofer diffraction by volumetric bodies of constant thickness. J. Opt. Soc. Am. A, 6, 5, pp. 617 - 626, 1989.

ThU18

THE NEW IR DYE FOR OPTICAL DISK MEMORY

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It is presented the method to get the tret-butilreplaced polimetilen dyes on the base 1-bensotioperil. salts. It is synthesized simmetric and antisimmetric structures this dyes with a big absorbing in the 720-810 nm region. We report about some particularities the centrifugations process for thin dye solution and its composition with polymers. It is shown that the more tret-butil groups is in simmetrical dye molecule, the less cristallisation process takes place in the recording layer. On the base this composition the thin amorphus films were gotten with the optical density, thickness, reflectivity and photostability matched the optical disk memory WORM demandes. With the help of the special elaborated on the home laser diode ILPN-780 installation it is fulfilled investigations energy sensitivity of the elaborated films at the recording mode and it was found the signal contrast and signal-to-noise ratio reading mode. The installation is provided the laser spot diameter on the film about 1 μm at the wave length 780 nm. The pulse power may be changeed from 0 to 50 mW and pulse width may be changed from 40 to 100 ns.

The sure recording of information on the film is fulfilled at 34 mJ/cm^2 and the signal-to-noise ratio more then 45 dB.

ThU19

LASER LEVEL-BY-LEVEL SYNTHESIS OF MODELS FROM COMPOSITE POWDER MATERIALS.

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A laser system of record on a flat field has been developed for investigation of the technologies of fast manufacturing of models using level-by-level selective sintering of powder materials or volumetric polymer processing. The system provides vector-raster laser beam scanning. A CO_2 laser of a 30 W power serves as the radiation source. The sampling step in the plane of processing's is 35 μm along the X coordinate and 17,5 μm along the Y and Z coordinate. The processing zone measures 200x300 mm2. The minimal record spot is 50 mkm. The exposure changes due to the change in the record pulse duration from 1 μs up to 1 ms.

The processes of models manufacturing by selective sintering of materials were investigated on homogeneous and heterodyne powder compositematerials with various grain dispersion. The composites included easily fusible powders based on polyvinyl chloride as the binder and the powders of various materials as the basis for layer formation. The basis powders were classified and prepared at the Institute of Solid Chemistry and Processing of Mineral Raw Materials, SB RAS,Novosibirsk.

Experiments on manufacturing the models by selective layer-by-layer evaporation were carried out on samples of PMMA, polyurethane and rubber up to 5 mm thick. The depth of the layer formed by output of one cross-section of the model varied with the exposure changing from 0.05 to 0.3 mm.

ThU20

MULTI-IMAGE STEREOGRAMS IN 3D VISUALIZATION

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To display spatial three-dimensional images is one of the actual today's problems in science and engineering. In the paper, a version of the stereographic method [1] is proposed and studied.

The lens array creates a matrix of point light sources in its focal plane. In front of it, the partially transparent transmission mask is placed; the mask makes each point source visible or invisible for every allowed position of the viewer eye. The mask together with lens array can be called a multi-image stereogram. A viewer interprets two visible points as one far point. If all partial images for every allowed eye position are appropriate projections of the same object, the viewer can observe the spatial image of this object. The mask is printed in the printer on the transparency.

It is shown in the paper that stereograms can be built by means of the lens array (or holographic lens array) and the partially transparent mask. The appropriate software was developed. To build the testing stereograms (64 * 64 pixels) for 14 * 14 viewing positions, the necessary lens pitch is 2 mm and the printer resolution required is 300 dpi. The multi-image stereogram has two-dimensional motion parallax within a viewing region. With increasing the printer resolution and decreasing the lens pitch, the stereograms can be improved in resolution of partial projection and in number of viewing positions. With white light source, it is also possible to build color images. Stereograms printed over a photopolymer film with holographic lens array can be used as a "hard copy" of 3D objects.

1. M.Yamaguchi, T.Koyama, N.Ohyama, T.Honda, A Stereographic Display Using a Reflection Holographic Screen, Opt. Rev., vol. 1, No 2, pp. 191-194 (1994).

ThU21

NEW CRITERION FOR ORGANIC MOLECULES SELECTION IN INFORMATION-OPTICAL TWO - PHOTON TECHNOLOGIES

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The creation of 3D-memory and 3D-images with the use of two-photon absorption requires substances, ensuring high luminescence intensity. For a quantitative estimation of working molecules, suitable in these purposes, a criterion, which can be named as two-photon excited luminescence efficiency (TPELE), is proposed:

$$\mu = (\delta\eta) \times 10^{50},$$

where δ - two-photon absorption (TPA) cross section in sm^4 s/phot mol; η - quantum yield of luminecsence; 10^{50} - normalizing factor, reciprocal 1 GM (Goeppert-Mayer).

In the table parameters of some organic molecules are presented.

Substance	Solvent	Wavelength nm	TPA cross section	Quantum yield	μ
MSB	n-hexane	568	$6{,}9\ 10^{-48}$	0,94	648,6
Rhodamine 6G	ethanol	694,3	$1{,}8\ 10^{-48}$	0,94	169,2
	ethanol	1064	$1{,}2\ 10^{-49}$	0,94	11,3
DODCI	methanol	1064	$2{,}2\ 10^{-49}$	0,50	11,0
Rhodamine B	ethanol	1064	$1{,}3\ 10^{-49}$	0,70	9,1
POPOP	MCH	694,3	$8{,}0\ 10^{-50}$	0,93	7,4
Coumarine	ethanol	694,3	$1{,}0\ 10^{-49}$	0,45	4,5
Acridine Red	water	1064	$2{,}8\ 10^{-50}$	0,45	1,3
Naphthalene	monocr	532	$2{,}5\ 10^{-50}$	0,37	0,9
Antracene	ethanol	532	$1{,}7\ 10^{-50}$	0,30	0,5

MCH - methylcyclohexane

The table shows a much larger relative change in TPELE than in two-photon absorption cross-sections. This criterion's application will allow selectively to synthesize and to choose substances for 3D - memory and 3D - image realization.

ThU22

RESONANCE EXCITATION AND SELF-GENERATION OF PHOTOREFRACTIVE WAVES IN PHOTOREFRACTIVE CRYSTALS

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The results of experimental and theoretical investigations of the resonance excitation of photorefractive waves (moving holographic gratings) at recording of holograms by two beams one of which is periodically phase modulated with frequency Ω are presented. It is established that when the wave vector of a hologram k and frequency Ω satisfy the dispersion law $\Omega \approx (k\tau L)^{-1}$, where τ is the Maxwell relaxation time, L is the drift length, and $kL \gg 1$, a sharp resonance can be observed at the frequency dependence of the non-Bragg diffraction orders. The physical origin of this phenomenon is as follows: under the conditions mentioned above the interference pattern produced by the recording beams has the same wave vector and oscillation frequency as the corresponding photorefractive waves. As a consequence, the resonance excitation of these waves occurs.

The experiments were carried out in single crystals of $Bi_{12}SiO_{20}$ and $Bi_{12}TiO_{20}$. The excellent agreement between the theory and experiment was found and a sharp maximum was detected in accordance with the theoretical predictions.

It was also found experimentally that under definite conditions (a high contrast of the interference pattern, low k, and high electric field) self-generation of photorefractive waves takes place. In this case no phase modulation of the recording beams was provided, but the oscillation of self-generated waves were observed in the same frequency range where the resonance maximum was found in the presence of phase modulation. The theory of the effect taking into account the current instability in photorefractive crystals at holographic recording is suggested.

ThU23

STIMULATED RAMAN SCATTERING IN ALL-FIBER OPTICAL SWITCHING.

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A number of devices based on a Sagnac fiber interferometer, known also as the nonlinear loop mirror (NOLM), have been proposed for ultrafast switching [1-7]. A standard NOLM uses cross-phase modulation between co-propagating control and signal pulses to switch a signal pulse from one arm to the other. An ultrafast nonlinear response in fiber is generated through the optical Kerr effect. A noninterferometric device which could join switching and amplification functions would be very prospective for signal processing. Stimulated Raman scattering (SRS) may be considered as a potential mechanism for ultrafast switching and amplification because of its femtosecond response time. A common point of view is that the main drawback of SRS in fibers is its relatively high pump power requirements.

Here we describe and demonstrate Raman effect-based optical transistor and inverter. The control pulse power requirements for the Raman switch are expected to be practically the same as for the Kerr switch. Our calculations show that the Raman gain grows faster than the Kerr coefficient with an increase of germanium concentration. If highly germanium-doped fiber is used, then stimulated Raman scattering dominates over the nonlinear Kerr effect, resulting in the linear (at low Raman gain) and exponential (at greater Raman gain) transfer functions of the NOLM. An important advantage of this optical transistor is a possibility to obtain all-optical switching and amplification in a single device. We have demonstrated an optical switching of 100 ps pulses with an amplification factor of 10 in 20 mol.% germanium-doped fiber. An optical inverter with contrast ratio of 2 based on the unbalanced Sagnac interferometer have been presented.

1. A.N.Starodumov, Yu.O.Barmenkov, A.Martinez, I.Torres, L.A.Zenteno, Opt. Lett., (to be published) 1998.

ThU24

HIGHLY-EFFICIENT METASTABLE GRATINGS IN CdF_2:Ga

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We describe the physical mechanisms of writing, decay and other properties of holographic gratings in metastable defects known as DX center in the wide-gap, predominantly ionic semiconductor CdF_2:Ga. At the moment, this is the most promising representative of new class of holographic materials in which the local photorefractive response is due to a photoinduced transformation of the impurity center in the semiconducting crystal from a localized to a delocalized state in which free or weakly-bound electrons occur. Due to a difference in the polarizability of these states, the optical properties of the crystal are modified and reversible phase gratings arise in the interference pattern inside the crystal. The photoinduced change in the refractive index of the crystal in the transparency gap (~0.45-1.2 mm) increases quadratically with the wavelength. The high ionicity of the crystal ensures a large potential barrier separating the metastable and ground states of the Ga center (1.12 eV) which enables long-time persistent phenomena below T = 200 K, the highest for this class of materials. A relative diffraction efficiency of 94% was obtained at a total exposure fluence of 300 mJ/cm^2. Below 200 K the crystal can operate in quasi-static regime whereas above this T a dynamical regime is possible with relaxation time depending on T and N_{Ga} (at the moment $N_{Ga} \sim 10^{18}$ cm^{-3} is available). The use of these crystals in three-dimensional holographic optical memory devices and in holographic phase-conjugate mirrors for wave-front correction is considered.

ThU25

DEFORMATION OF BRAGG ANGLE OF DYNAMIC HOLOGRAM IN PHOTOREFRACTIVE MEDIA HAVING HIGH OPTICAL NONLINEARITY.

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Photorefractive media are promising materials for many applications. Illumination of the photorefractive medium by two interfering light beams excites a modulation of refractive index. The recording beams are diffracted to each other and modify a dynamic hologram (DH). The component of refractive index grating which shifted by $\pm\pi/2$ respectively to interferometric pattern provides the intensity coupling, the components in phase yields the phase coupling. Latter is a reason of hologram titling which provides the Bragg angle shift. In this paper we demonstrated, that high non-linearity of photorefractive medium produces, aside from a titling, a hologram curving which strongly depends on input beam intensities and an intensity ratio. The hologram curving, in its turn, produces the Bragg angle deformation being changed during hologram writing. The Bragg angle deformation also is observed in case of pure intensity coupling, which yields intensity beam ratio changes and, as result, interferometric pattern contrast and photoinduced refractive index variation across the slab. It should be noticed, that in this case only the Bragg angle deformation is observed, but no shifting. Observed in [1] Bragg angle deformations can be accounted both by hologram titling and by changing of modulation depth of refractive index across the slab. Figures below show theoretical slops of Bragg angle deformation in case of photorefractive grating curving (fig.1) and in case of photoinduced refractive index variation (fig. 2), τ is relaxation time of the medium.
Thus, reasons of the Bragg angle deformations of DH written in photorefractive medium having strong photoresponse are discussed in this paper.

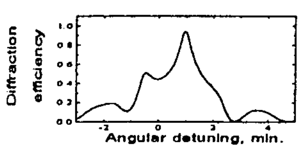

Fig.1. Bragg angle deformation due to grating curving for the time of 3τ.

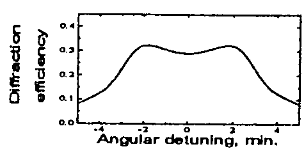

Fig.2. Bragg angle deformation due to photoindused refractive index variation vs hologram depth for the time of 2τ.

1. R. De Vre, M. Jeganathan, J. Wilde, L. Hesselink. Opt.Lett. **19**, 910 (1994).

ThU26

PHOTOINDUCED COLOR CENTERS IN A SERIES OF MANGANESE DOPED RARE-EARTH ORTHOALUMINATES

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Recently, we reported a strong photorefractive effect, accompanied with a color change, in manganese doped crystals of yttrium orthoaluminate (Mn:$YAlO_3$) [1]. A permanent, high-efficiency diffraction grating, erasable by heating, implied the potential of Mn:$YAlO_3$ as an optical storage material. We tentatively explained the color change by reversible disproportionation reaction $2Mn^{4+} \Leftrightarrow Mn^{3+} + Mn^{5+}$. In this work, we present results of a more detailed investigation of Mn color centers in orthoaluminates of yttrium, gadolinium and lanthanum.

The crystals were grown by the conventional Czochralski technique in an rf-heated iridium crucible under nitrogen atmosphere with 0.2% of oxygen. Some Mn:$YAlO_3$ crystals were codoped with Ce or Ca in order to provide charge compensation for different Mn valence states substituting Y or Al. The crystals were characterized with electron microprobe, chemical analysis, optical absorption and emission spectroscopy, and electron paramagnetic resonance. We found that:

1. Mn^{2+} and Mn^{4+} ions were present in all as-grown Mn:$YAlO_3$ crystals.
2. Mn^{3+} and Mn^{5+} states formed in photoexcited crystals, Mn^{4+} concentration was reduced, and Mn^{2+} concentration was unchanged.
3. Addition of Ce enhanced the formation of Mn^{3+} ions and reduced Mn^{4+} concentration in as-grown crystals. In Ca-containing crystals, the Mn^{4+} concentration was increased and Mn^{5+} ions formed before the photoexcitation.
4. The photoinduced coloration and associated with it refraction index change can be obtained in Mn doped Gd and La orthoaluminates as well, however the coloration there was less stable than that in Mn:$YAlO_3$.

[1] G.B. Loutts, et al., to be published in Phys. Rev. B, January 15, 1998.

Jelly-Like Dye Doped Gelatine - New Photosensitive Material for Holography and DFB Lasers

ThU27

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Dye doped jelly-like gelatine is proposed as a new photosensitive material for recording periodic gratings. So far only dichromated gelatine was known to be suitable for optical recording the holographic gratings and in this case recording requires certain chemical processing. We have found for the first time that the dye doped jelly-like gelatine without activation by dichromate of ammonium and without any subsequent chemical processing may be as well employed for the purpose. Such medium allows to record stationary 3-dimentional gratings with high spatial resolution. The material may be also used for fabrication dye lasers with permanent distributed feedback.

Rhodamine 6G doped gelatin jelly of high optical quality was prepared by special technology. Spatial gratings, produced inside a jelly sample by the interference fringes of second harmonic of YAG:Nd-laser. Such gratings remained permanent and stable during a long period of time (many days). The jelly-like sample with prerecorded grating exhibits DFB laser action under pumping with a single beam of YAG:Nd-laser second harmonic at a frequency corresponding to the period of the grating. Permanent "spatial memory" allows to record several gratings of different period in the same site of jelly. It was observed experimentally that the dye laser with such DFB-structure operates simultaneously on several appropriate spectral lines. It was also found that the wavelength temperature stability of the jelly DFB laser is equal to 0,05 nm/degree which is more than three times better than of the similar DFB dye laser with ethanol solution.

We believe that apart of DFB lasers the proposed new material may be used for many applications in holography.

18:30-20:00 **RED HALL**

ThV - New Nonlinear Optical Materials and Physics of Low-Dimensional Structures

ThV1 Linear and nonlinear optical properties of silicon micro- and nanocrystallites

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Optical properties of micro- and nanocrystallites have received a great deal of attention recently [1,2]. These properties can be used for designing new optoelectronic devices.

Silicon crystallites produced by low temperature plasma enhanced chemical vapor deposition technique have been shown size-dependent photoluminescent [3] and second harmonic generation (SHG) responses. The crystalline volume fraction was estimated by using Raman spectra. The grain sizes of crystallites were measured by using x-ray diffraction. Luminescent properties and SHG response of oxidized Si nanocrystals are different from those of hydrogen-terminated nc-Si and dependent of surface chemistry. The structural chemical properties of poly-Si films were studied by means of Fourier-transformed infrared spectroscopy, and UV/VIS/IR transmission spectrophotometry. The size-dependent SHG response of poly-Si films is sensitive to hydrogen or oxygen coverage, which can change the media from asymmetric to symmetric configuration. The SHG intensity for poly-Si films deposited by using $SiH_4/SiF_4/H_2$ gas mixture as function of such deposition conditions as hydrogen flow rate, silicon tetrafluoride flow rate, deposition temperature was studied.

References

1. A.A.Seraphin et al., Mat.Res.Soc.Symp.Proc.358, (1995) 205.
2. O.A.Aktsipetrov et al., Zh.Eksp.Teor.Fiz. 107, (1995) 96.
3. D.E. Milovzorov et al, J. Electrochem. Soc. (in press).

Photoinduced polarization response of polyacetylene nanoparticles from picoseconds to milliseconds

ThV2

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In *trans*-polyacetylene, *trans*-$(CH)_x$, the initial photoexcitation of the π- conjugated chain nonradiatively relaxes into the coupled electron-lattice state. These states are known to appear on the sub-picosecond time scale and to be long-lived ($\sim$ 0.1 ms) and neutral. They are observed as a photoinduced absorption band below the fundumental absorption edge of *trans*-$(CH)_x$.

We have carried out both cw and picosecond polarization pump-probe experiments on nonoriented $(CH)_x$ films. These films comprise of crystalline $(CH)_x$ particles with size of $\sim$ 10 nm dispersed in a matrix of polyvinilbuteral. The experiments have been performed under resonant photoexcitation. Linearly polarized pump was absorbed in the film inducing a small change in the polarization state of a linearly polarized probe with the wavelength in the transparency range of the film.

In the picosecond experiments we have observed small photoinduced birefringence ($\delta n \sim 10^{-9}$ for the pump fluence $\sim 1\mu J/cm^2$) that persists after the photoexcitation. The sign of the photoinduced polarization response is determined by the mutual orientation of the pump and probe polarizations. Futhermore, we have found that the photoinduced birefringence reveals a gyrotropic contribution, i.e. circular birefringence.

The observation of the gyrotropic effect implies breaking of the central symmetry of the initially plain *trans*-$(CH)_x$ chain. This symmetry breaking can be caused by excitation of torsional vibrations which distort the plain geometry of the π-conjugated chain. We suppose that these torsional vibrations play a key role in the photophysics of *trans*-$(CH)_x$ because they mix the states of opposite symmetry, i.e. A_g and B_u states, making possible fast non-adiabatic transition between the charged ($1B_u$) and neutral (A_g) states. The following scenario of fast photoexcitation relaxation in the *trans*-$(CH)_x$ chain is discussed: photoexcitaion of the optically allowed $1B_u$ state and coupled lattice vibrations; intramolecular vibrational redistribution that excites the torsional vibrations; internal conversion of the $1B_u$ state into the neutral long-lived state. We present the data demonstrating that this scenario can occur on the picosecond time scale. Further relaxation of photoexcitation, in particular possible singlet-triplet transitions, is dicsussed.

POLARIZATION-SENSITIVE FOUR-WAVE INTERACTION IN SEMICONDUCTOR MICROCAVITY: EFFECTS OF THE EXCITON-EXCITON CORRELATION

ThV3

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Optical properties of normal-mode-coupling, called "cavity-polariton" modes, in semiconductor microcavity have been studied extensively[1] at high as well as low density regime. The study of high density excitation of such a system elucidates the role of the many body Coulomb effects and the observed features have been well explained by the semiconductor Bloch equations (SBE's)[2]. At low density regime the four-particle correlation becomes pronounced which requires a theoretical treatment beyond SBE's. Correspondingly, the experimental studies of the nonlinear optical effects in semiconductor microcavities at low density regime may bring new aspects of many body effects.

We report the results of frequency degenerate four-wave mixing in semiconductor microcavity under weak excitation in self-pumped phase conjugation geometry [3]. The experiments were performed for several polarization configurations at various cavity-exciton detunings. The theory of the polarization-sensitive four-wave interaction in the microcavity has been developed in the framework of the elastic four-polariton scattering approach. The scattering potential originates from the departure of the cavity confined excitons from the pure boson and accounts for the state filling effect, repulsion between the exciton with the same angular momenta and attraction between excitons with opposite angular momenta. We have found that the signal wave intensities for different polarization configurations give a unique relationship between relative contributions of the above effects to the scattering potential. The contributions of the attractive exciton interaction and state-filling effect to the scattering potential have been found comparable while the repulsive interaction's contribution was much less than others.

The properties of the cavity polaritons may be approached by the few level polarization-sensitive models that should account for the symmetry of the two-exciton and biexciton states. We have shown that such a model gives the same result as the polariton scattering approach providing that the polariton nature of the microcavity electric field is properly accounted.

1. C.Weisbuch et al, Phys.Rev.Lett. **69**, 3314 (1992); T.B.Norris et al, Phys.Rev.B **50**, 14663 (1995); H.Wang et al, Phys.Rev.B **51**, 14713 (1995).
2. F.Jahnke et al, Phys.Rev.Lett. **77**, 5257 (1997); M.Kira et al, Phys.Rev.Lett. **79**, 5170 (1998).
3. M.Kuwata-Gonokami et al, Phys.Rev.Lett. **79**, 1341 (1997); R.Shimano et al, Jpn. Journ.Appl. Phys.Lett. **34**, 817 (1995).

ThV4

Quantum size effects in sandwiches with wedge-like layers.

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The results on the investigation of the influence of quantum size effects on magnetic and magneto-optical properties of MBE grown sandwiches with wedge-like layer (Au / Co-wedge / Au(001) and Au/ Cu-wedge /14Å NiFe/ Au(001)) are presented. The typical slope of Co- and Cu-wedge was respectively equal to 2.7 and 1.35 Å/mm. The investigations of the hysteresis and magneto-optical properties of the studied samples were performed on magneto-optical micro-magnetometer by means of the transverse Kerr effect (TKE). The size of the light spot on the sample was ~ 0.03 mm. The Co- and Cu-thickness dependencies of hysteresis properties and TKE were measured at the fixed photon energy $\hbar\omega$ of the incident light. The scan of the light spot was done across a middle line of the samples along its length. It was discovered that in Au/ Co-wedge/ Au (001) sandwich the value of TKE oscillated as Co-wedge thickness t_{Co} varies between 0 and 20 Å. It was found that the period of these oscillations Λ is equal to ~ 4-5 Å and is dependent on $\hbar\omega$. At $t_{Co} > 20$ Å TKE has the linear dependence on t_{Co} that are in according with the calculated values from Maxwell equations. It was established that in Au/ Cu-wedge/15Å NiFe/Au (001) sandwich the value of TKE has the complicated dependence on t_{Cu}. In particular, the peak of TKE is evident at $t_{Cu} \sim 5.5$ Å; in the t_{Cu} -thickness range from 6 to 8 Å TKE value decreases abruptly; at $t_{Cu} > 8$ Å TKE decreases slowly and has small oscillations of its magnitude. It was found that the period of these oscillations Λ is equal to ~ 7 Å. Because of the small amplitude of TKE oscillations the appreciable change of Λ did not be discovered when the values of $\hbar\omega$ were varied. It was established that t_{Co}– and t_{Cu}– dependencies of the local values of the saturation field of the studied sandwiches are analogous to those of TKE. It was proved that TKE oscillations are caused by the variation of quantum well energy levels as the width of the wells (i.e. the thickness of Co- or Cu- layer) is varied.

ThV5

PHOTOPROCESSES ON THE SURFASE OF NANOPOROUS SEMICONDUCTORS.

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Laser action on surface is an effective method of selective control of surface states. It allows to understand peculiarities of surface structure. It is important to rule luminescent properties of semiconductor (e.g. porous Si (PS)), because photoluminecence depends on surface passivation and kind of desorption states. Photoprocesses induced by laser radiation (IR and visible) on surfaces of nanoporous Si and GaAs have been investigated by mass-spectroscopy, luminescent and absorption spectroscopy.

It was found the desorption of H_2, Si, SiO and formation of C_2H_2 molecules under irradiation. C_2H_2 is the result of decay of organic compounds, stayed in sample. It was shown that PS surface contains the variety of bonds Si-Si, Si-H and Si-O deformed, therefore surface layer can easy be desorbed under irradiation with laser fluence $q<3*10^7$ W/sm^2. Research of laser action on the nanoporous GaAs surface carried out first allow to make conclusions about the structure of porous surface. The principal products of desorption are As, As_2, As_4, as well as As_4 desorbing yet at $q=3*10^6$ W/sm^2. The dependence of As_4 mass-peak amplitude from q is unmonotonous. Results of experiments shown that surface layer does not contain a lot of Ga, therefore properties of surface are ruled by properties of As.

ThV6

MULTIPHOTON TRANSITIONS IN QUANTUM WELLS

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A theory of multiphoton generation of electron-hole pairs and intersubband multiphoton transitions in semiconductors with quantum wells (QW) is presented. The multiphoton transitions occur due to strong IR or far-IR irradiation. In contrast to the case of usual bulk materials, some novel essential features are found in the process of multiphoton generation when the field is directed along the axis of nanostructure growth. The n-photon generation rates, W_n, were calculated using the n-th order perturbation theory in terms of coupling between electrons and electromagnetic wave field. At not very low photon energies, $\hbar\omega \geq 10^{-1}$ eV, the perturbation theory is applicable up to the light intensities $J \approx 1$ GW/cm^2. For the QW widths $d \approx 10^{-6}$ cm, the principal channels of the multiphoton process involve a sequence of intermediate virtual states in adjacent size-quantization subbands of the valence and conduction bands. Simple approximate formulas are derived for W_n with arbitrary n values. It is shown that, in wide-gap QW materials, the rates W_n at given intensity values J decrease more slowly with increasing n than in the same bulk materials. At the photon energies $\hbar\omega \approx 10^{-2}$ eV the multiphoton transitions between size-quantization subbands of the valence or conduction band are of significant interest. In this case, the applicability criteria for the perturbation theory are violated at moderate intensities J. The rates of intersubband multiphoton transitions, R_n, are calculated by using the method of step-by-step diagonalization of the electron-photon coupling Hamiltonian. The method makes it possible to calculate R_n in the first order approximation with respect to the nondiagonal part of the modified Hamiltonian and to take into account the reemission of photons, the Stark shifts of the levels and the interference of a large number of different multiphoton absorption channels. It is shown that the rates R_n depend non-monotonously on the far IR radiation intensity J and decrease slowly with increasing n. At $J \approx 2 \div 3$ MW/cm^2 the values R_n differ essentially from those obtained in the perturbation theory calculation. It is found that n-photon intersubband transitions with different $n \leq 7$ can be observed simultaneously.

ThV7

OPTICAL PROCESSES DUE TO EXCITONS AND BIEXCITONS IN A MICROCAVITY EMBEDDED QUANTUM WELL

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In this paper we present a theoretical investigation of one- and two- photon absorption of weak probe light, respectively, by exciton polaritons (P) and biexcitons (B), and also biexciton luminescence in the presence of a strong laser pulse in a planar microcavity embedded quantum well (QW). The strong pulse pumps the lower branch P into the B and the both states undergo the optical Stark splitting, wich manifests oneself in the above mentioned optical spectra. It is assumed that the exciton is two-dimensional, confined in the QW, and only the lowest $1s$ heavy hole exciton with dispersion is taken into consideration. The interaction takes place only between excitons and the photons inside the microcavity with the same in-plane wave vector **k**. The cavity mode photon has a cutoff frequency, which depends on the cavity length. The case of TE polarization is considered. The B is formed from two lower branch P. It is assumed that the strong field is turned on adiabatically. The matrix element of the $P \leftrightarrow B$ transition depends on the strength of the strong field and includes the Hopfield's coefficients. We obtain the quasienergy spectrum and the Raby frequency Ω. The probability of the transition between the ground state of the QW and the lower branch P under the action of the weak probe light has two peaks of different intensity, spaced 2Ω apart. The probability of two-photon transition on quasienergy levels in the biexciton region of the spectrum is obtained in the second order of perturbation theory upon exciton-photon interaction. The B absorption spectrum also contains two peaks spaced 2Ω apart. In the biexciton luminescence spectrum three maxima appear which are shifted with respect to the maximum in the case without pumping. The numerical estimations of the probabilities are made for $Zn_{1-x}Cd_xSe/ZnSe$ QW.

The amplification of exciton-photon interaction in the microcavity leads to the increasing of Raby frequency. Due to the quantization of the photon mode, for the photon energies of pump and probe fields forbidden regions appear at **k** where the polariton effect is most significant. For the same reason the optical Stark effect is more pronounced in the biexciton two-photon absorption spectra.

ThV8

FULLEREN-LIKE SILICON CLUSTERS: LASER SYNTHESIS AND FEATURES

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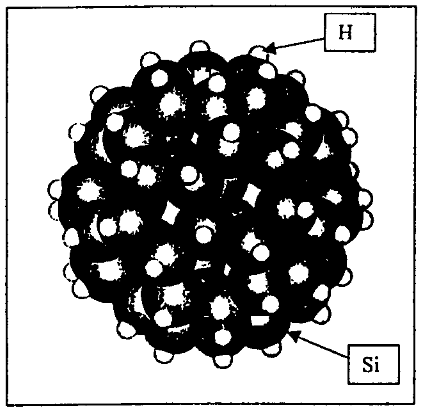
The principal possibility of creating multi-atom fullerene-like silicon clusters, first of all of the $Si_{60}H_{60}$ type, in highly ionised laser spark plasma initiated in compressed mixture of silan SiH_4 (20%) and argon was investigated. In experimental study a mixture of SiH_4 and noble gas argon under total pressure of 1-5 atmosphere was sealed into a reactor chamber with optical windows. A laser beam of YAG:Nd laser with the pulse energy up to 0.8 J at λ=532 nm, pulse duration ~16 ns, repetition rate 1-5 Hz and divergence ~0.3 mrad was focused through the optical window into the centre of the chamber and, as a result, in silan an intense laser spark was formed. Due to the high temperature, pressure, and intensive radiation in the region of laser spark silan was decomposed to ionised Silicon and Hydrogen atoms which have a high reactive capability, and various complicated compounds (among which multi-atom fullerene-like silicon clusters may exist) have appeared in the chamber. Brown thin porous films on quartz substrates as well as water and ethanol solutions of these compounds were created. Absorption and fluorescence spectra of the samples as well as their mass-spectra were investigated. Some of the compounds have a maximum of fluorescence in the region of 370-380 nm and 420-430 nm. The chemical modeling gives the shown possible stable silicon fullerene structure $Si_{60}H_{60}$ with diamiter about 12 A°.



ThV9

DIAGNOSTICS OF THERMOPHYSICAL PROPERTIES OF POROUS SILICON BY LASER OPTOACOUSTIC METHOD

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The porous silicon is of great importance in science and technology due to it's unique properties [1-2]. Therefore the determination of characteristics of this material such as porosity, heat conductivity etc. is very actual.

The new method of the the broad-band acoustic spectroscopy with laser excitation of ultrasound [3] is proposed for determinaton of characteristics of porous silicon. Measurements are possible in broad frequency band (up to 100MHz) in local areas of objects by using this method.

The plates of monocrystalline silicon with porous layer etched on their surfaces are investigated. The thickness of porous layer, its porosity are determinated, the method of measurement of heat conductivity is proposed.

Calculation of thickness of porous layer and porosity of the samples is made by the comparison of spectra of acoustic signals, propagated through the sample with porous layer and the monocrystalline one. To calculate the thickness of the porous layer, ultrasound is excited in the experimental sample. To determinate the porosity of the porous layer, ultrasound is excited in the special optoacoustic source (ink on the surface of the sample).

The experimental data permits the determination of heat conductivity of porous silicon by using the method of transfer functions of thermooptical excitation of ultrasound in heat-conductive media [3].

References:

1. A. Uhlir, Bell Syst. Tchnol. J. 35, 333(1956)
2. L. T. Canham, Appl. Phys. Lett. v.57, №10, p. 1046. (1990)
3. V.E. Gusev, A.A. Karabutov. Laser Optoacoustics. AIP., N.Y. (1993)

ThV10

The role of local field enhancement effect in fractal nano-aggregates of colloidal silver on the process of their photostimulated formation

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Summary
A phenomenon of giant (up to 10^{10} times) enhancement in rate of aggregation of fractal nano-structures, caused by light in silver hydrosols and spectral features of its photo-emission nature were discovered [1]. That means that rate of photo-stimulated aggregations must be determined by the value of photo-emission current from the particles. Similar conclusion was made in experiments, where increase of photo-coagulation rate of Ag nano-particles in aerosols was found to be accompanied by the increase of photoelectron emission [2]. We have shown that photo-aggregation of nano-particles into fractal structures in colloids is stipulated not only by one-photon, but by two-photon photo-effect too, even at intensities of illuminating light on the order of solar. Investigations of dependence of photo-induced aggregation rate on wavelength of illuminating light $\dot{A}(\lambda)$ within the wavelength range of $\lambda = 360 \div 1050nm$ have revealed a "red threshold" of this process-$\lambda_t = 1050nm$ [1]. Besides that, a deep intermediate minimum $\lambda_m = 520 \div 550nm$ occurs in the dependence which is close to the experimental value of photo-effect red threshold for the system a metal - electrolyte solution. That allows to distinguish two parts of the curve: the first one (I), corresponding to a wavelength range $\lambda_1 = 360 \div 550nm$, and the second ($II$) - to $\lambda_2 = 550 \div 1050nm$. Ratio λ_t/λ_m is approximately equal to two, which indicates that photo-aggregation process within the range of $\lambda_2 = 550 \div 1050nm$ might be caused by two-photon photo-effect. Low efficiency of two-photon processes basically expected under such low intensity of light (on the order of $I = 1 \div 3mW/cm^2$), can be enhanced by a contribution of local-field (LF) effect which is characteristic of fractal aggregates. Evaluations show that under characteristic of our experiment light intensities generated LF range from some hundreds to several thousands V/cm. These values are equivalent of light intensities on the order of several tens kW/cm^2. For identification of order of photo-emission process the dependence of photo-induced aggregation rate on the intensity of illuminating light $\dot{A}(I)$ was investigated. One sample was illuminated by light with wavelength within the range (I) ($\lambda_1 = 450nm$), another - by radiation within the range (II) ($\lambda_2 = 700nm$). Experimental curves are close to linear one ($\dot{A} \propto I$) within the range (I) and to squared dependence ($\dot{A} \propto I^2$) within the range (II) which are in a good agreement with behavior of density of one- and two-photon photo-emission currents $j_1 \propto I$, $j_2 \propto I^2$.

1. S.V.Karpov. A.L.Basko, S.V.Koshelev et al., Colloid J., **59**, p.765, 1997.
2. H.Burtscher, A.Schmidt-Ott, Phys.Rev.Lett., **48**, 25, p.1734, 1982.

ThV11

LIGHT-INDUCED ULTRAFAST BLEACHING IN FILMS OF DIFFERENT ARRANGING OF SEMICONDUCTOR NANOCRYSTALS: MATERIALS

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An understanding of the mechanisms which contribute to ultrafast optical bleaching in deposited films activated with nanometer-sized crystallites (nanocrystals - NCs) is important for the design and optimization of a number of optoelectronic devices [1]. In the present communication, I report on recent result dealing with the composition, spectroscopy and nonlinear optical (NLO) properties of thin-film samples with different arranging of ZnSe, CdS and CdSe crystallites, the matrix-free films with closely packed (polycrystalline – *poly*-films) and non-closely packed crystallites (microcrystalline – μc-films), as well as NCs embedded into microcrystalline and amorphous thin-film matrices. Data obtained from TEM microphotograps, UV-VIS-NIR absorption and luminescence spectroscopy measurements are compared with the NLO properties of test samples under irradiation with 352 nm and 528 nm (Nd:glass laser) 3-ps-pulses.

In particular, in the case of *poly*-films, closely-packed crystallites show an optical behaviour similar to that detected in the host single-crystalline semiconductors. In the case of both the μc-films and the *nc*-samples, amplitudes of the near band edge bleaching clearly increases. Semiconductor NCs formed in thin-film matrices (*nc*-composites) show an optical behaviour similar to that in quantum dot media, and its photostability increases when the matrices are microcrystalline. Beside that, these new materials [2] show QW-bleaching the efficiencies that depend on the NC material/matrix material volume ratio as well as ultrafast (≤1 and ≈7–10 ps) components of bleaching decay the efficiencies of which correlate with the near surface NC-matrix regions/NC core volume ratio and depend on excitation power.

1. O.V.Goncharova, A.V.Demin, Patents Nos.2078358, 2096815, 1997 (Russia).
2. O.V.Goncharova, A.V.Demin, Patents Nos.2089656, 2103846, 1997 (Russia).

SYNTHESIS AND PROPERTIES OF THREE-DIMENSIONAL LATTICES EXHIBITING PHOTONIC PSEUDOGAP IN THE VISIBLE RANGE

ThV12

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The concept of the photonic crystal which is three dimensional lattice with periodic modulation of refractive index offers a route towards novel optical materials with the controlled photon density of states. In spite of the significant progress in the theory for practical realization of photonic crystals for the optical range a number of principal physico-chemical problems have to be solved to fabricate a 3D periodic microstructure with omnidirectional band gap for optical waves. Recently we reported on the first step towards solid state 3D superlattices based on colloidal self-organized close packed crystals of the period 0.2-0.3 μm [1]. These superstructures consist of spherical silica globules. For further progress towards omnidirectional photonic band gap the refraction index modulation should be enhanced and the topology of the structure should be optimized.

In the present contribution we report on the synthesis and properties of three-dimensional dielectric superstructures based on colloidal SiO_2-crystal in which other oxides, TiO_2 and Fe_2O_3 have been synthesized in the course of sequential sol-gel reactions. In this case the lattice of closed packed spherical globules with air spacing is replaced by a 3D network of highly refractive dielectric with silica spacing. The obtained structures show pronounced spectrally selective transmission and reflection due to pseudogap in the visible range. The first results of impregnating these structures with resonant inclusions possessing nonlinear response are discussed and a possibility of novel harmonic generators, optical switches and light emitters due to interplay of electronic and morphological resonances is considered.

1. V. N. Bogomolov, S.V. Gaponenko et al. Phys. Rev. E 55, 7619-7625 (1997).

DIFFRACTION AND FOCUSING OF EXTREMELY SHORT OPTICAL PULSES: GENERALIZATION OF THE SOMMERFELD INTEGRAL.

ThV13

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We report specific features of diffraction and focusing of ultrashort optical pulses with duration about one optical period. Proceeding from Sommerfeld integral [1], we arrived the equation describing the diffraction of an arbitrary pulse:

$$E(x,y,z,t)=\frac{1}{2\pi c}\iint\frac{\partial}{\partial t}E(x',y',0,t-R/c)\frac{z}{R^2}dx'dy',$$

where R is the distance between point of integration with coordinates $(x',y',0)$ on the flat screen and the point of observation (x,y,z).

In the case of diffraction by a circular aperture, when the field in the incident pulse does not depend on transverse coordinate ρ, the diffraction of a pulse results in the appearance of two heteropolar pulses on the axis of the aperture which are identical to the incident one, but are separated by a time interval $\Delta t = r_0^2/2zc$. If the incident pulse consists of one period of the harmonic oscillations, $E_0(t)=E_0\sin(2\pi t/\tau_0)$ for $0\le t\le\tau_0$ and $E_0(t)=0$ for $t<0$ and $t>\tau_0$, then for $z\rangle\rangle L_d = r_0^2/2c\tau_0$ the form of energy density $W(\rho)$ is nearly Gaussian, with the width of the distribution $r_0(z)$ which can be approximated by the expression $r_0(z)=r_0(1+(z/5L_d)^2)^{1/2}$.

We obtain, that in the case of diffraction of a pulse with a Gaussian transverse amplitude distribution, that consists of a single period of the electromagnetic oscillations, its energy density as a function of the transverse coordinate remains Gaussian over all distances, with the radius $r_0(z)=r_0(1+(z/L_G)^2)^{1/2}$, where $L_G=\pi r_0^2/c\tau_0$ just as in case of monochromatic radiation with $\lambda = c\tau_0$.

Using spectral approach to the diffraction effects in focused beams we derived the equation describing the field in the focal plane for the pulses $E(\rho,0,t)=E(t)e^{-\rho^2/r_0^2}$ with an arbitrary pulse shape E(t):

$$E(\rho,R_\Phi,t)=\frac{1}{(2\pi)^{1/2}}\int_{-\infty}^{\infty}F(\omega)\frac{ir_0^2\omega}{2R_\Phi c}\exp\left(i\omega\left(t-\frac{R_\Phi}{c}\right)\right)\exp\left(-\frac{i\rho^2\omega}{2R_\Phi c}-\frac{\rho^2\omega^2r_0^2}{4R_\Phi^2c}\right)d\omega,$$

where R_Φ - focal length, $F(\omega)$ - Fourier transform of E(t).

It was shown that the focusing efficiency of monochromatic wave and one period pulse is approximately equal if the incident beams have Gaussian spatial distribution.

REFERENSES

1.V.A. Aleshkevich and V.K. Peterson, JETP Lett. 66, 344 (1997).

ThV14

ELECTRONS AND PHOTONS IN MESOSCOPIC STRUCTURES: QUANTUM DOTS IN A PHOTONIC CRYSTAL AND IN A MICROCAVITY

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Mesoscopic structures with a characteristic size either of the order of an electron de Broglie wavelength in semiconductors (1-10 nm) or close to the optical photon wavelength (100-1000 nm) exhibit non-trivial properties due to modified electron or photon density of states. Three-dimensional spatial confinement of electrons in nanocrystals ("quantum dots") results in size-dependent energies and probabilities of optical transitions[1]. The photon density of states can be modified in structures with strong modulation of the refractive index in three dimensions (photonic crystals)[2] and in microcavities. Because of the essentially different electron and photon wavelengths, electron and photon density of states can be engineered separately within the same mesostructure. In this letter we report on synthesis and properties of semiconductor quantum dots corresponding to the strong confinement limit embedded either in a photonic crystal exhibiting a pseudogap or in a planar microcavity. We show that the interplay of electron and photon confinement within the same structure opens a way towards novel light sources with controllable spontaneous emission. Spontaneous emission which is not an inherent property of quantum systems but a result of their interaction with electromagnetic vacuum can be either promoted or inhibited depending on the modification of the photon density of states in a given mesostructure.

1. S. V. Gaponenko, Optical Properties of Semiconductor Nanocrystals, Cambridge Univ. Press, Cambridge 1998.
2. V. N. Bogomolov, S.V. Gaponenko et al. Phys. Rev. E 55, 7619-7625 (1997).

ThV15

THE REFRACTIVE INDEX OF $LiNaCO_3$ CRYSTAL

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The index of refraction measurements were performed using the prism method with the incident beam being 90° to the entrance face of prism. Since $LiNaCO_3$ crystal is biaxial (we observed the conoscopic pattern characteristic to biaxial crystal with the angle between optic axes 6.7° at room temperature for a single domain sample), two prisms with the aperture of 10x10 mm^2 were fabricated to measure all three indices of refraction. A value of error was ±0.0003 for refractive indices measurements. The indices of refraction were measured at five wavelengths in the range between 0.4358 mkm and 0.6328 mkm. The results are given in next table:

λ, mkm	0.4358	0.4416	0.5461	0.5780	0.6328
n_1	1.5601	1.5593	1.5491	1.5471	1.5443
n_2	1.4164	1.4161	1.4111	1.4101	1.4088

We used an equation for dispersion of refractive index in following form: $n^2=A+B/(\lambda^2-C)+D\lambda^2$, here λ is the vacuum wavelength in units of microns, and A, B, C, and D are constants chosen to give the best agreement with the measured data. In our case, when we have five experimental points only, the best agreement with the results of nonlinear optical experiments and calculated data is achieved by using two Sellmeier equations for refractive index. Taking in account four experimental points from violet or red range of wavelength we can calculate Sellmeier coefficients for both refractive indices. The results of calculations are given below

		A	B	C	D
n_1	IR	2.3500010	0.01450281	0.02055961	-0.00868111
	UV	2.2606753	0.04272805	-0.08440872	0.09155947
n_2	IR	1.9559575	0.01036332	-0.02368492	0.01051978
	UV	2.01352823	-0.01918613	0.06402657	-0.2626656

The accuracy of the index of refraction fits in visible range was checked by comparison of the experimentally observed phase matching angle and angular acceptance to the calculated values. This calculation gives phase-matching angles 18.6° (type-I), and 25.4° (type-II) for doubling of YAG laser radiation in $LiNaCO_3$ crystal, and 34.8° (type-I) and 42.6° (type-II) for doubling of YAG second harmonic. Experimentally we obtained the following results: PM (type I) angles are 20.2° for SHG and 34.6° for FHG in the plane of optical axes, and 18° and 33.5° in the perpendicular plane correspondingly. PM (type II) angles are 26.5° for SHG and 41.8° for FHG in the plane of optical axes, and 24.8° and 40.9° in the perpendicular plane correspondingly. As can be seen, these experimental results are in good agreement with calculated figures.

Calculated angular acceptance for SHG of YAG laser radiation is 0.503 mrad•cm for type I, experimental result is 0.54 mrad•cm, in good agreement with the calculated figure as well.

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FAST GROWN "ACID" KDP CRYSTALS: FREQUENCY CONVERSION IN UV REGION.

ThV16

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An alteration of the KDP salt solution acidity changes it's properties such as KDP salt solubility, stability of the KDP solution, solution density, solution viscosity, solution heat capacity, etc. It also changes state of impurities in the solution and characteristics of interaction between growing faces of the crystal and solution impurities. As a result kinetics of crystallization changes, habit and physical properties of the grown crystal change too.

In this work we report the results of our investigations which was done for high rate crystal growth processes ($R_z \approx 20$ mm/day). The KDP crystals were grown by standard fast growth method [1]. For preparing of the solutions we used pure KDP salt, bidistilled water and water solution of phosphoric acid. Temperature of saturation of the KDP salt solution was determined by "trial crystal" method. It was 62±0.1 °Ñ in all experiments. The solution was filtered, overheated up to 80°C and stirred during two days. First one KDP crystal was grown from the stechiometric solution. This crystal was cut to prepare seeds for following experiments. In all experiments regeneration of the seed was done under the same supersaturation $\sigma \approx 3\%$. After full regeneration of the seed, temperature of the solution was linear decreased to achieve starting supersaturation and then it was decreased to maintain a rate of crystal growth about $R_z \approx 20$ mm/day. We grew crystals from next solutions:

#exp.	1	2	3	4	5	6	7	8	9
C(gH_3PO_4/100gH_2O)	0	1.6	5.03	10.2	15.0	20.0	22.3	25.0	29.9

An average growth rate along Z axis was 16÷18 mm/day for all crystals. The growth rate in X and Y directions was really the same in all experiments. All Crystals were perfect and hadn't any visible inclusions.

The UV absorption spectra of crystals were measured by spectrophotometer Shimadzu. These spectra didn't depend on solution acidity for pyramidal part of the crystal, but there were a significant dependence for prismatic part. It was found that absorption at 270 nm decreases and at 200 nm increases with increasing of solution acidity. Apparently, phosphoric acid reacts with impurities which are responsible for absorption band at 270 nm, but simultaneously the solution of phosphoric acid adds to the KDP solution some impurities which are responsible for the absorption band at 200 nm. Measurements of absorption spectra of phosphoric acid water solutions show that increase of acid concentration results in increase of absorption at 200 nm.

1. Zaitseva N.P., Smolsky I.L., Rashkovich L.N., *Sov. Phys.-Crystallog.* **36** (1991) 198.

THE ABSORPTION OF BLUE-GREEN AND 1064 nm LIGHT IN LITHIUM NIOBATE BY A PHOTOTHERMAL TECHNIQUE

ThV17

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Optical absorption in the transparency range of lithium niobate severely limits high average power applications of this material: absorption coefficients less than 0.01 cm-1 cause thermal lensing whenever cw power exceeds 1 W. To accurately measure such low absorption coefficients, a photothermal technique has been developed with a sensitivity of 1 ppm/cm and temporal resolution of 10 ms. The technique relies on thermal distortion of a weak and comparatively wide probe beam (less than 0.5 mW at 633 nm, focused to a 0.1 mm waist) by a pump beam from a chopped cw-source, focused to a 0.05 mm waist. Maximum phase-locked signals caused by self-interference between distorted and undistorted parts of the probe beam were detected roughly one Rayleigh length from the probe beam waist.

Absorption coefficients less than 0.001cm-1 were detected in congruent, oxygen-annealed crystals at 1064 nm while a typical figure for blue-green light absorption was 0.02cm-1 for pump powers below 0.1 W. The absorption of blue-green light was found to be both nonlinear and time-dependent. Steady-state absorption coefficients increased by nearly a factor of two as pump power was raised to 1 W. Build-up to the steady-state value was observed to occur with two time constants, one on a tenths-of-seconds scale and the other on a one-minute scale. Initial absorptions were typically half the steady-state value.

The absorption of 1064 nm itself was linear with pump power and showed no time dependence. However, though the He-Ne-laser probe beam was weak, red-induced photo-bleaching of 1064 nm absorption (represented by a 10% to 30% decrease of the signal after 30 min) was detected.

Green-induced infrared absorption was investigated by adding a second, cw blue-green pump to the chopped 1064 nm pump. A complex response having both instant and power-dependent tenths-of-seconds time constants was observed. Reduced lithium niobate crystals with absorption coefficients near 3 cm-1 at 1064 nm showed similar green-induced infrared absorption, suggesting that reduced niobium may give rise to this type of behavior.

SPECTROSCOPIC INVESTIGATIONS OF CHROMIUM DOPED CALCIUM TETRAGERMANATE SINGLE CRYSTALS

ThV18

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SUMMARY

A new material, chromium doped calcium tetragermanate, $Cr:CaGe_4O_9$ had been grown and investigated for the first time. The single crystals were grown in air ambient by floating zone melting technique. From absorption spectrum (fig. 1) of the crystals, typical for Cr^{3+} - doped materials, crystal field parameters were calculated: Dq = 1740 cm^{-1}, B = 576 cm^{-1}, and C = 3038 cm^{-1} . Fluorescence spectrum (fig. 2) is of «alexandrite type», i.e. sharp R-line (transition $^2E \rightarrow {}^4A_2$) plus broadband emission peaking at 740 nm (vibronic transition $^4T_2 \rightarrow {}^4A_2$). The emission cross-section of broadband fluorescence was calculated from an assumption of 100% - fluorescent decay of excited state to be σ = $4.2*10^{-21}$ cm^2. Fluorescence decay is nearly exponential with lifetime at room temperature τ = 260 µsec. Both σ and τ are comparable with that parameters of alexandrite. Preliminary investigations show that this material may have prospectives of using as an active medium of new tunable solid-state laser of near IR region.

Fig.1 Absorption spectrum of $Cr:CaGe_4O_9$ at 300K

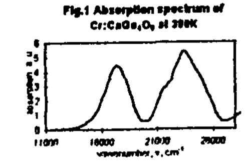
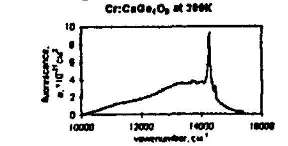


Fig.2 Fluorescence spectrum of $Cr:CaGe_4O_9$ at 300K



NONLINEAR OPTICAL PROPERTIES OF CYANINE DYES J-AGGREGATES IN THIN FILMS MEASURED BY Z-SCAN TECHNIQUE

ThV19

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The aggregates on the basis of molecular structures are currently receiving considerable attention by unique optical and nonlinear optical properties [1-3]. The cyanine dyes form well-odered one-dimensional aggregates are known as J-aggregates. In the case of J aggregates the broad monomer absorption band evolves into an intense, and narrow red-shifted absorption peak (J-peak) upon aggregation. The J-peak corresponds to motionally narrowed Frenkel-exciton transition [4].

It was found by degenerate and nondegenerate four-wave scattering that the J- aggregates in an aqueous solution [1,2] and in thin polymer films [3] have a large resonant third-order optical non-linearity $|\chi^{(3)}|\sim10^{-7}\div10^{-6}$ esu for relaxation times $10^{-13}\div10^{-12}$ s.

The present report studies the dispersion of $Im\chi^{(3)}$ and $Re\chi^{(3)}$ of cyanine dyes J-aggregates in sub-micron films by z-scan technique. J-aggregates are usually embedded in amorphous media that possess a greater structural disorder as compared to molecular crystals. We have studied thin films without any stabilization polymer.

It was found that for those films the values of $Im\chi^{(3)}$, $Re\chi^{(3)}$ near to J-peak were $\sim10^{-5}$ esu. The films have a negative sign for $Im\chi^{(3)}$ but at a low-frequency side of J-peak the sign changes on positive. The maximum of $|Im\chi^{(3)}(\omega)|$ is observed close to J-peak. The measurements of width of linear and nonlinear absorption spectra demonstrated that half-width of nonlinear spectrum was 1.7÷1.9 times smaller then linear one for several samples. The measured dependence of $Re\chi^{(3)}(\omega)$ has compared with the value calculated by Kramers-Kronig transformation. For optical dense samples the contribution of a thermal nonlinearity is displayed.

During our experiments on excitation of J-aggregates films by green or yellow light red emission with wavelength close to 630 nm was observed. The dynamic bleaching of J-peak and darkening in its vicinity and also red emission can be explained by four-level model.

1. Y. Wang J. Opt. Soc. Am., v.B8, N5, p.981-986, 1991.
2. V.L.Bogdanov, E.N.Viktorova, S.V.Kulay,A.C.Spiro JETP lett. v.53, N2, p.100, 1991.
3. F.A.Zhuravlev, N.A.Orlova, V.V.Shelkovnikov et. al. JETP lett. v.56, N5, p.260, 1992.
4. E.W. Knapp Chem. Phys. v.85, p.73-82, 1984.

ThV20

ENHANCEMENT OF TWO-PHOTON INITIATED COLORATION BY ENERGY TRANSFER FROM DYE TO PHOTOCHROMIC MOLECULES IN A POLYMER FILMS

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Recently the interest in studying of two-photon phenomena in organic substances is renewed. The reason of this interest is caused by prospects of photochromic substances using in 3D memory devices based on the principle of two-photon absorption (TPA) [1]. Moreover, TPA can be used for pumping of upconversion lasers [2].

Recent measurements show that photochromic substances have relatively low TPA cross-sections (about 10^{-50} $cm^4 \cdot s$). Unfortunately, such values do not allow to use compact low energy lasers in 3D memory devices.

The efficiency of two-photon excited photoreactions can be enlarged using an energy transfer from high TPA dye molecules to photochromic molecules. So, the effective TPA cross section of photochromic molecules has been enlarged.

In this paper some mixtures of photochromic and organic dye substances are investigated to enhance a photochromic coloration output.

References

1. Koroteev N.I., Magnitskii S.A., Shubin V.V., Sokoluk N.T., Jpn. J. Appl. Phys. 36 (1997), 424.

2. J.D.Bhawalkar, G.S.He, C.-K.Park,C.F.Zhao, G.Ruland, P.N.Prasad, Optics Communications, 124 (1996), 33

ThV21

NONLINEAR OPTICAL PROPERTIES OF NOVEL PHOSPHATE GLASSES DOPED WITH CdSe QUANTUM DOTS

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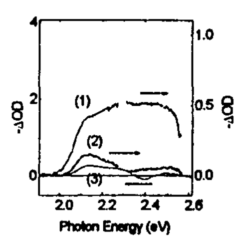
In this talk we report the results of the investigation of the nonlinear optical properties of the CdSe-doped phosphate glass using picosecond and nanosecond pump-probe techniques. The annealing conditions necessary for the growth of the QD's in the phosphate glass are much softer in comparison with silicate semiconductor-doped glass: temperature (420-440°C) is lower as well as the annealing procedure is shorter (several minutes and tens of minutes). This is due to low (about 435 °C) characteristic temperature and low viscosity for the phosphate glass. The CdSe QD's in strong confinement regime (in our sample the mean particle radius~2.9 nm) exhibit the induced absorption and multicomponent-decayed bleaching at room temperature which are explained by excitation of one and two *eh* pair states. Figure shows 20-ps and 393-ps delay time differential absorption spectra (curves (1) and (2) respectively). About 50 percent of the bleaching relaxes in 140 ps at probe photon energy of 2.14 eV and in 25 ps at one in the region of 2.35-2.5 eV. The differential absorption spectrum from nanosecond pump-probe experiments shows an induced absorption around 2.4 eV.



Photoluminescence was measured at room temperature. The photoluminescence spectra are observed to depend on excitation intensity. Increasing of excitation leads to appearing of a new luminescence peak which related to the 1Se→2S3/2 quantum size transitions.

Figure. Differential absorption spectra of the phosphate glass doped with CdSe quantum dots.

ThV22

NONLINEARITY OF LiF CRYSTAL WITH F_2^- COLOR CENTERS

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Lithium fluoride crystal with F_2^- color centers (CC) is known to be a reliable saturable absorber for neodymium lasers. Our earlier investigation of nonlinearity in LiF:F_2^- CC crystal were done using degenerate four wave mixing technique [1].

In this report the results on investigation of nonlinearity using Z-scan technique under irradiation with nano and picosecond YAG:Nd laser pulses are presented. Z-scan measurements in LiF:F_2^- CC crystal were done with pico and nanosecond laser pulses. Electro-optically Q-switched and passively mode locked YAG:Nd laser (1064 nm) with pulse duration 35 ps and 10 Hz repetition rate was used as a light source in picosecond experiments. The laser beam was focused into LiF:F_2^- CC samples 20 mm long with various initial transmission. The result of the division of the "closed" by the "open aperture" data for CC crystal with T_0(1064 nm) = 40%, absorption coefficient α_{1064} = 0.48 cm^{-1}) and pump pulse energy 5.5 μJ is shown in the Fig. It exhibits behavior typical to nonlinear medium with a positive third order nonlinearity, resulting in self focusing. The value of the real part of nonlinear susceptibility estimated from the unsaturated data was found to be $\chi_{real}^{(3)} = 1.6\times10^{-11}$ esu in the above crystal. It was found that this value linearly depends on the concentration of F_2^- CC and remains 10-20 times higher that that in pure LiF host material. The positive nonlinear susceptibility is described due to CC nonlinearity.

1. T. T. Basiev, P. G. Zverev, S. B. Mirov, and S. Pal, SPIE 1500, 65 (1991).

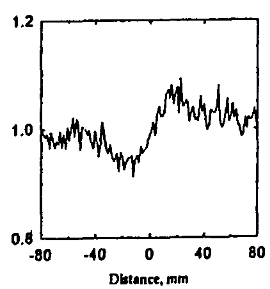

Fig. The result of division of the "closed" by the "open aperture" Z-scan data sets in LiF:F_2^- CC crystal with 40% initial transmission. It exhibits positive nonlinearity typical for self-focusing materials.

ThV23

Two-Photon Photopolymerization as a Method to Fabricate Three-Dimensional Periodic Microstructures

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Two-photon photopolymerization [1] implies that a photopolymerizable material transparent at the frequency of incident laser radiation can efficiently absorb simultaneously two quanta of incident light field. Due to its nonlinear character, two-photon absorption provides much better spatial resolution of photosolidification in a photopolymerizable material irradiated with a focused laser beam (or with a pair of noncollinear focused beams with different frequencies) as compared with a photopolymerization technique based on one-photon absorption. However, the most important advantage of the two-photon technique is that this approach makes it possible to implement photopolymerization in the bulk of a photopolymerizable material [2].

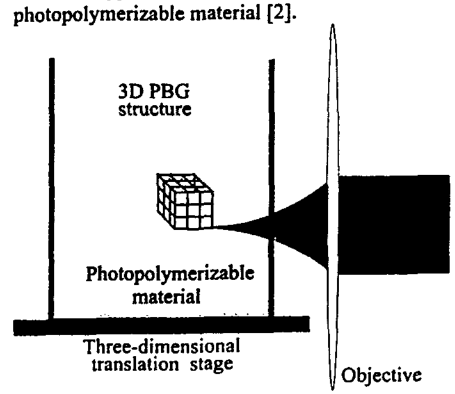

Fig. 1. Fabrication of a 3D periodic structure by means of two-photon photopolymerization.

In the implemented scheme of two-photon photopolymerization, a sample of a photopolymerizable material irradiated with 810-nm 150-fs pulses of a Ti:sapphire laser is scanned with respect to laser beam(s) by means of a high-precision computer-controlled translation stage in three dimensions, which results in the formation of a 3D periodic microstructure (Fig. 1). Subsequently, unsolified material is removed, and the voids can be filled with a material with required optical properties. Such a procedure provides an opportunity to fabricate periodic three-dimensional micro- and submicrostructures. In particular, this technique offers much promise for the fabrication of photonic crystals in the visible range.

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References

1. J.H. Strickler and W.W. Webb, *Opt. Lett.*, 16, 1780 (1991).
2. S. Maruo, O. Nakamura, and S. Kawata, *Opt. Lett.*, 22, 132 (1997).

ThV24

NONLINEAR FREQUENCY CONVERSION AND ELECTROOPTICAL EFFECT IN HALOGENOSUBSTITUTED NITRODIPHENYLS

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Results of the tests for the second harmonics generation in powders of halogenosubstituted nitrodiphenyls are presented. The p,p'-iodine-nitrodiphenyl shows largest second harmonics intensity. This material possesses also better transparency in blue spectrum region.

P,p'-iodine-nitrodiphenyl single crystals with good optical quality and typical sizes of 7*10*15 mm^3 were grown from solution. For the crystals obtained transmission spectra of polarised and unpolarised light and refraction index were measured. The Zelmeier approximation coefficients of refraction index dispersion within the spectral range of 0.45 - 1.15 μm were calculated.

The components of nonlinear susceptibility tensor were measured with an original method using frequency interference fringes. Main advantages of the method in comparison to others are considered. Electrooptical coefficients of p,p'-iodine-nitrodiphenyl single crystals were measured too. The comparison of the nonlinear susceptibility values at high frequency $d_{333}(2\omega,\omega,\omega) = 115\cdot10^{-12}$ m/V and low frequency $d_{333}(0,\omega,-\omega) = 45\cdot10^{-12}$ m/V points to large electronic contribution to the electrooptical effect.

In our opinion the most perspective region of application for p,p'-iodine-nitrodiphenyl crystals is in light modulation. The Miller's constant for this crystal is one of the largest among investigated as far as we know.

ThV25

BULK NONLINEAR OPTICAL SUPERLATTICE IN CZOCHRALSKI GROWN LITHIUM NIOBATE SINGLE CRYSTAL

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Lithium niobate single crystal with periodical domain structure (optical superperlattice) is a promising material for nonlinear optical conversions using quasi-phase matching (QPM). The regular bulk domain structures with a period 4-30 mkm were formed during crystal growth by the Czochralski method. Double doped (Y, Eu,Nd and Mg as a second dopant) $LiNbO_3$ was grown along the normal to the (0112) face and along [2110] direction (X-axis). The face on the growth front gave rise to a system of flat domains, so that the normal to the superlattice boundaries located in the YZ plane was oriented at 57 to the Z-axis. X-axis growth direction is a good practice for using the highest nonlinear coefficient d_{33} in the QPM nonlinear conversions. The linear grating profile (refractive index modulation) and nonlinear grating profile (modulation of the quadratic nonlinearity) were determined for Y:Mg:$LiNbO_3$ crystal, grown along the normal to the face [1]. Simultaneous generation of second (532 nm) and third (355 nm) harmonics of Nd:YAG laser radiation were generated in different crystal sections with 6,2 and 5,7 mkm period of domain structure respectively [2]. The correlation between periodic domain structure and impurity modulation along the growth directions were studied by the selective chemical etching and by the wave dispersive X-ray microanalysis in the SEM. We observed earlier [3] that the concentration of the Eu or Nd and Mg impurities are in antiphase, and rare-earth ion modulation period coincide with period of the superlattice In this work we discuss the peculiarities of periodical domain structure and the profile of impurity modulation associated with the different growth directions in the framework of the Burton-Prim-Slichter theory.

1. A.L.Aleksandrovskii, O.A.Gliko, I.I.Naumova, V.I.Pryalkin, Quantum. Electronics(Russia, Published in English by Turbion Publ., London) 26, 641(1996).
2. A.L.Aleksandrovskii, I.I. Naumova, and V.V.Tarasenko, Ferroelectrics, 141, 147 (1993).
3. I.I.Naumova, N.F.Evlanova, O.A.Gliko, S.V.Lavrishchev, Ferroelectrics, , 190, 107 (1997) and Journal of Crystal Growth, 181. 160 (1997).

ThV26

Nb - DOPED $Bi_{12}TiO_{20}$ - A NEW PHOTOREFRACTIVE CRYSTALS

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Photorefractive crystals with sillenite-type structure are effective photoconductors in the visible region. Taking into account their electrooptic properties, they may be used as active elements in photorefraction, light modulation, and holographic devices. At the present time, much attention has been given to the influence of doping on the properties of photorefractive sillenite-type crystals such as the index of refraction, optical rotation, and linear electrooptic coefficient.

In this work we first present our experimental results on the electrooptical parameters and the dispersion of optical rotation for $Bi_{12}TiO_{20}$ doped with Nb (from 0,05 to 0,2 wt %). For comparison, similar data obtained for undoped crystals are also presented.

$Bi_{12}TiO_{20}$ single crystals doped with niobium were grown by the modified Czochralski technique (dopants were added in the form of Nb_2O_5). The optical rotation decreases moderately with increasing degree of Nb doping in $Bi_{12}TiO_{20}$ crystals and attains a value of $\rho = 5.9$ deg/mm at $\lambda = 633$ nm and concentration of niobium $C_{Nb} = 0,2$ wt %. For comparison, a value of the optical rotation for undoped bismuth titanate is equal to 6,5 deg/mm at $\lambda = 633$nm. The electrooptic module r_{41} and electrooptic efficiency $r_{41}n_0^3$ of the niobium-doped crystals are identical to those of undoped bismuth titanate, namely, these values are equal to $r_{41} = (5,8\pm0,3)\cdot10^{-12}$ m/V and $r_{41}n_0^3 = (9,6\pm0,6)\cdot10^{-11}$ m/V at $\lambda = 633$ nm.

All those experiments gives us the possibility to assume that a new photorefractive $Bi_{12}TiO_{20}$ single crystals doped with niobium can be used as image-recording media for real-time holographic interferometry and spatial light modulation.

ThV27

OPTICAL AND ELECTROOPTICAL PROPERTIES OF VANADIUM-DOPED BISMUTH ZINCATE

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Electro-optic photoconducting crystals of the sillenite type such as $Bi_{12}SiO_{20}$, $Bi_{12}GeO_{20}$ are currently widely used as active elements in space-time light modulator, hologram recording, spatial optical switching, and others optical devices. It is well known that the index of refraction, optical rotation, and linear electrooptic coefficient are basic optical parameters determining the photorefractive behavior of sillenite-type compounds.

At present paper we report on the dispersion of optical rotation and of the refractive index, and the electrooptical parameters of photorefractive bismuth zincate-vanadate ($Bi_{38}Zn_{0,7}V_{0,3}O_{58}$) single crystals with sillenite structure, which were grown by the TSSG ("top-seeded solution growth") technique.

λ, nm	n	ρ, °/mm	r_{41}, pm/V
500	2,656	12,2	5,2
540	2,613	10,4	5,20
580	2,588	9,0	5,22
600	2,576	8,3	5,27
633	2,562	7,4	5,30
670	2,548	6,5	5,26

Spectral dependencies of the refractive index $n(\lambda)$, optical rotation $\rho(\lambda)$, and electrooptic coefficient r_{41} for BZnVO are listed in Table. In comparison to undoped $Bi_{38}ZnO_{58}$ (BZnO), crystals of $Bi_{38}Zn_{0,7}V_{0,3}O_{58}$ (BZnVO) exhibit a much smaller optical rotation, namely, a values of the optical rotation for BZnVO and undoped BZnO crystals are equal to 7,8 deg/mm and 10,5 deg/mm at λ=633 nm, respectively.

Thus, in vanadium-doped BZnO crystals, $[VO_4]^{3-}$ optically active complexes, which provide an independent contribution to the optical rotation, are formed. Because the position of the charge-transfer transition for $[VO_4]^{3-}$ shifts toward lower frequencies, the negative contribution to the optical rotation increases, and this results in a decreasing optical rotation by the BZnVO crystal.

ThV28

$PbMo_{1-x}W_xO_4$ - NEW FAST ACTING INORGANIC SCINTILLATOR

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Having ideal structural identity with binary $PbMoO_4$ (PM) and $PbWO_4$ (PW) compounds - extreme members of $PbO\text{-}MoO_3\text{-}WO_3$ ternary system – mixed $PbMo_{1-x}W_xO_4$ crystals combines the good optical and spectroscopic parameters of PW and relatively high mechanical(strength) properties of PM.

Field of application: α -, β -, γ - and proton radiation monitoring. Monitoring of high energy radiation for technology and nuclear physic investigations.

Scintillating parameters of new material are given in table (excitation by α -particles, CzI-Tl here - as base material for comparison):

№№	Material	B_A, %	ΔR, %	τ_e, ns	λ_m, mn	Z_{eff}	χ_0, cm
1	CsI-Tl	100	8	650	540	5	1,71
2	$Bi_4Ge_3O_{12}$	31	12 ÷ 40	105(300)	480	77	1,05
3	$PbMoO_4$	2 ÷ 5	~ 100	~ 10	480	69	1,13
4	$PbMo_{1-x}W_xO_4$	25 ÷ 26	70 ÷ 80	5 ÷ 10	475 ÷ 480	68 ÷ 70	0,94 ÷ 1,08

Comparative analysis of table data allows to estimate values and deficiencies of the new inorganic scintillator:

-relatively low scintillation effectiveness of B_A (lower than CzI-Tl and $Bi_4Ge_3O_{12}$ ones); - sufficiently high atomic number (Z_{eff}); it is lower than $Bi_4Ge_3O_{12}$ only; - response (τ_e) is higher than CzI-Tl one more than hundredfold and than $Bi_4Ge_3O_{12}$ one more than twentyfold (in other words - this material has much higher loaded capacity); - high chemical resistance(absolutely nongygroscopic in comparison with base material, CzI-Tl); - high thermal stability (absence of phase transitions up to melting point:1080-1100°C in dependence on Mo/W ratio); - ability to monitoring of β- and γ- radiation with scintillating effectiveness about 20% in comparison with base material CzI-Tl; - high radiation resistance(colourless after radiation).

The additional field of application - is acoustooptics: this material has high "figure of merit"(coefficient M_2) which is not lower than $PbMoO_4$ has.

ThV29

SYNTHESIS, ATOMIC STRUCTURE AND PROPERTIES OF THE $Rb_{1-x}Cs_xTiOPO_4$ CRYSTALS

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Single crystals of the KTP family including $KTiOPO_4$ (KTP), $RbTiOPO_4$, $TlTiOPO_4$ and others or analogous arsenates attract recently much attention as perspective materials for non-linear optics as well as new ferroelectrics and superionic conductors. Physical properties of these crystals can be changed over wide limits by way of isomorphous substitutions, and the present paper deals with the precise X-ray analysis and studies of physical properties of the mixed composition crystals grown in the system $RbTiOPO_4$ (RTP) - $CsTiOPO_4$ (CTP).

The investigations of the $Rb_{1-x}Cs_xTiOPO_4$ ceramic samples and crystals show that the RTP - CTP system is pseudobinary with the limited solid solutions with the KTP - type and CTP (pyrochlore) - type structures. The width of the former region is $0 \le x \le 0.2$ at 670°C and diminishes as the temperature increases. At more high Cs concentration and more high temperatures the pyrochlore - type phase is more stabile. Furthermore, under some conditions a ternary compound $Cs_7Ti_3P_7O_{27}$ can appear.

A series of single crystals of solid solutions with the KTP-type structure were grown from the melts containing various concentrations (from 20 to 50 at.%) of Cs. The chemical composition of the crystals obtained from the melt with 20 at.% Cs was found to be $Rb_{0.95}Cs_{0.05}TiOPO_4$ and its atomic structure was refined by means of precise X-ray analysis. The cell parameters at room temperature are a = 12.959(1), b = 6.501(1), and c = 10.544(2) A, the space group is $Pna2_1$. A small partial substitution of Rb by Cs leads to substantially more loose crystal structure with incomplete occupation of Ti, P, and O - positions. At the same time such substitution is accompanied with the lowering of the ferroelectric transition point.

ThV30 Composition of the First Coordination Sphere of Lanthanide in Glassy Semiconductors.

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Currently, considerable interest has been aroused in the applications of vitreous semiconductors (VS) as luminescent media. On one hand, this interest is accounted for by the absence of high-energy phonons in the vibration spectra unlike most known laser materials and, as a result, by the low probability of multiphonon nonradiative relaxation in lanthanide ions. The second reason is that these materials exhibit a band gap close to the energy of laser transitions in lanthanide ions. This permits optical pumping through the interband absorption of a VS matrix followed by the transmission of excitation to lanthanide ions. In order to accomplish this mechanism of optical pumping of lanthanide atoms, it is important to take into account not only the relationship between the luminescent transition energy of lanthanide and band gap of VS, but also location of energy levels of lanthanide in the energy band structure of VS. The energy-level position of extrinsic lanthanide centers in the energy band structure of a VS depends on the composition of the environment of lanthanide. VS provide a wide variation in the composition not only of cation sublattice, but also of anionic sublattice, which can incorporate S, Se, Te, all halogens and dopants of oxygen. This makes it necessary to control the composition of the environment of lanthanide.

The chosen method of control over the composition of the first coordination sphere is based on the spectral shift observations in the absorption bands of lanthanide ions under changes in the degree of ionicity of the bonds. The first coordination sphere of neodymium in glasses of the germanium chalcogenide - gallium chalcogenide system (0.85 GeS2-xChx . 0.15Ga2S3-yChy, where Ch=O, Se, Te) is studied. It is shown that the spectral shift in absorption bands of neodymium is a linear function of the mean electronegativity of chalcogens involved in the VS, which indicates the coincidence between the average composition of the first coordination sphere of neodymium ions and the composition of anionic subsystem in the VS.

ThV31 NONLINEAR MAGNETIC-OPTICAL KERR ERRECT AND SHG INTERFEROMETRY IN THIN Co_xCu_{1-x} GRANULAR FILMS

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The magnetization induced second harmonic generation (SHG) is intensively used recently for studying the surface magnetizm. Nonlinear magneto-optical Kerr effect (NOMOKE) manifesting itself in magnetoinduced changes of the SHG intensity and/or in the polarization of the second harmonic (SH) wave, has been shown to exceed sufficiently the magneto-optical Kerr effect (MOKE) for a variety of systems. In this paper NOMOKE in Co_xCu_{1-x} granular films is observed revealing the magnetization induced changes of the SHG intensity, azimuthal anisotropy and phase.

The samples studied are granular Co_xCu_{1-x} films 200 nm thick prepared by the double e-beam gun deposition system. The output of a Q-switched YAG:Nd^{3+} laser at 1064 nm is used for the NOMOKE experiments. The azimuthal anisotropy of the SHG response observed testify the existence of the dipolar axis in the film. The comparison of MOKE and NOMOKE both in transversal and polar configurations shows that the magnitudes of NOMOKE exceed the linear analogue more than an order of magnitude. The direct measurements of the magnetization induced SH wave phase shift is carried out by the SHG interferometry.

Large values of the magnetoinduced SHG effects that are odd in magnetization can be explained by the interference of the magnetization induced and independent from the magnetization crystallographic contributions to the SH field. In the corresponding phenomenological description the contributions from the bulk and surface (both dependent on the magnetization and independent from it) are treated. It is shown that in spite of the expected small values of magnetization dependent components of the nonlinear susceptibility the net effect in magnetoinduced SHG can be significant.

ThV32

Paper has been withdrawn

ThV33 THE ENHANCEMENT OF SECOND HARMONIC GENERATION IN A METAL ISLAND FILM DUE TO SPATIAL DISORDER

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The enhancement of the optical second harmonic generation (SHG) in metal island films has been associated with the lack of the inversion symmetry due to particle shape and size fluctuations [1]. In this work we study theoretically a new mechanism of enhancement of the second-order optical nonlinearity in a disordered array of identical metal spheres. We take into account the inversion symmetry breaking caused by fluctuations in positions of the spheres. This leads to the arising of non-zero quadratic susceptibility of dipole origin in this system. The minimal configuration for which this effect occurs is 3 spheres. An analytical expression for the dipole moment oscillating at doubled frequency 2ω is obtained for the system consisting of 3 spheres with dipole-dipole interaction. The second harmonic response of two-dimensional ensemble of spheres is calculated in a low-density limit using the "ternary approximation" by averaging the square of the surface polarization $P^2(2\omega)$ over various three-sphere configurations and exhibits the following dependence on the sphere radius R:

$$P^2(2\omega) \propto R^{-4}.$$

1. O.A. Aktsipetrov, P.V. Elyutin, A.A. Fedyanin, A.A. Nikulin, A.N. Rubtsov, Surf. Scie, 1995, v.**325**, p.343-355.

ThV34

FREQUENCY RESPONSE OF THE ANOMALOUS ABSORPTION OF ELECTROMAGNETIC WAVES IN AN ULTRA-THIN FILM

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This paper analyses the effect of a non-zero real part of the layer permittivity on the anomalous absorption of electromagnetic waves in uniform and non-uniform layers. This effect was shown to be opposite for TE and TM electromagnetic waves. For example, if the real part increases to large positive values, the absolute absorptivity maximum decreases for TM waves, but increases for TE waves. If the real part goes to large negative values, the absorptivity maximum decreases for TE waves and increases for TM waves.

Frequency dependencies of the absorptivities of TE and TM waves in a CaF_2 thin film between two media with $\varepsilon_1 = 3$, $\varepsilon_3 = 1$ display sharp maximums (up to 100%) near the frequency of transverse optical phonons ω_{T0}. These maximums are slightly shifted from ω_{T0}, and this is explained by the effect of the real part of the layer permittivity. Both these maximums have typical half-widths $\sim 0.17 \times 10^{13}$ rad/s.

A very interesting aspect of the anomalous absorption of TM waves is the presence of another maximum of absorption near the frequency of longitudinal optical phonons where the layer permittivity is very small. This maximum also reaches 100% at an optimal layer thickness of about ten nanometers, which is definitely much less than the wavelength and the wave penetration depth in the material of the layer. This new type of anomalous absorption (NAA) is also explained by a strong increase of local electric field in the layer, but it is significantly different from the anomalous absorption in a layer with large permittivity. For example, NAA takes place only for TM waves, and displays an absorptivity maximum of 100% at the critical angle where the conventional anomalous absorption of TM waves gives zero absorptivity.

ThV35

FEMTOSECOND LASER NANOLITOGRAPHY USING LOCAL FIELD NEAR STM TIP

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The nanolithography technique is proposed and realized experementally using the local field of femtosecond laser pulses enhanced in a submicron region due to lighting rod effect and/or to the excitation of plasma resonances in STM tip - substrate system. Surface topography analysis in STM mode demonstrates the controlled surface modification in a suitable regime of intensity parameters and femtosecond laser pulses focusing in the STM tip region. The mechanisms of nanolocal photoinduced surface modification are discussed.

The surface of the sample was modified by femtosecond laser radiation focused in the region of STM tunnel junction. The radiation of Ti:Sa laser with wavelengths 812 and 406 nm, pulse duration 40-45 fs and repetition rate 82 MHz was used.

The dependence of radiation effects on exposition time, power and other controlling parameters is investigated.

Yu.E.Lozovik, A.V.Klyuchnik, in: "The Dielectric Function of Condensed Systems", Eds. L.V.Keldysh et. al., Elsevier Science Publisher B.V.,1987.
A.V.Klyuchnik, Yu.E.Lozovik, A.B.Oparin, Phys.Lett.A179,372(1993)

ThV36 EVAPORATION EFFECT ON LASER-INDUCED MELTING AND SOLIDIFICATION IN NEAR SURFACE LAYER OF COMPOUND SEMICONDUCTORS CONTAINING VOLATILE COMPONENT

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Due to heat transfer the surface evaporation may effect on laser-induced phase transition (melting, solidification) in semiconductors, containing volatile components [1]. In present paper we report numerical simulation of the phase transitions in CdTe and CdHgTe initiated by pulsed laser irradiation in vacuum. It was made for cases of ruby (λ = 694 nm, τ = 20 ns) and KrF-laser (λ = 248 nm, τ = 15 ns) treatments. The simulation was based on solution of thermoconductivity equation. Heat and particle flows through the surface were calculated according to Herz - Knudsen formula.

Temperature profiles, particle flows through the surface, the depths of the solidified layer and the layer with changed composition were calculated. Obtained results demonstrate the strong influence of evaporation of volatile components (Cd, Hg, etc.) of compound on solidification followed laser induced melting. Possibility of solidification starting from outer surface of semiconductor is shown. Since the surface solidification in contrast to epitaxial one is free from orienting action of substrate, it is likely to be the main reason for defect formation. In our experiments on laser irradiation of CdTe and CdHgTe stoichiometry deterioration and high defectiveness of near-surface layer were registered. Results of the simulation allow to explain these experimental facts.

Reference:

1. P.K.Kashkarov, V.Yu.Timoshenko, N.G.Chechenin, A.N.Obraztsov. Laser Physics 2, 5, 790 (1992).

ThV37 SECOND HARMONIC GENERATION WITH FEMTOSECOND LASER PULSES FROM THE METALLIC GRATINGS WITH THE VARIOUS PERIODIC RELIEF.

[1]A.A.Angeluts, [2]I.F.Salakhutdinov, [1]A.A.Goncharov, [1]N.I.Koroteev, [3]Yu.E.Lozovik, [3]S.P.Merkulova, [1]M.M.Nazarov, [2]V.A.Sychugov, [1]A.P.Shkurinov

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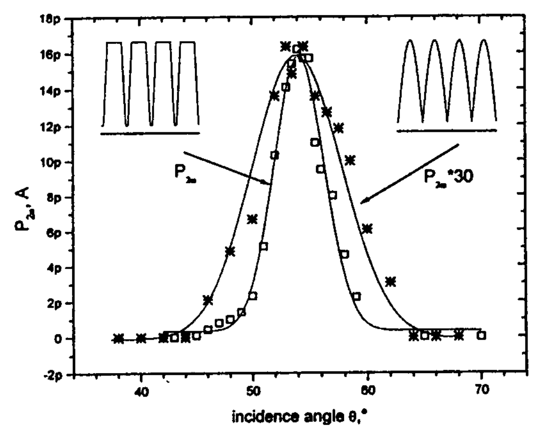
Second Harmonic Generation (SHG) from the metallic surfaces is a subject of intensive studies because if its applications in spectroscopy of molecules in solutions and in films. In this publication we present new results on studies the SHG from the metallic gratings with the various relief. The femtosecond laser pulses of CW Ti:Sapphire we used in the experiments possess high peak power with the lower average ~~one~~ power to avoid damage of the sample. We studied the grating with the various relief profile and we found out the strong influence, on the SHG intensity, of the ~~existence of~~ high (second, third etc) harmonics of special relief. On the figure we demonstrate the SHG intensity versus the incident angle for two indicated gratings profiles. We analyse conditions of existence of localized plasma excita-tions and their role in SHG.



ThV38 Growth and Spectroscopy of Cr^{4+}:Ca_2GeO_4 and Li_2MgSiO_4, a New Near-Infrared Tunable Laser Crystals

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Cr^{4+} in tetrahedral occupation first identified as the laser ion in forsterite (Mg_2SiO_4) proved to be very interesting for near IR tunable laser application. The demonstration of laser operation of Cr^{4+}-doped forsterite rapidly extended in other crystalline media such as $Y_3Al_5O_{12}$, Ca_2GeO_4 [1,2,3]. Growing interest in tetrahedrally coordinated Cr^{4+}-doped crystals has generated intensive search of new materials and its spectroscopic study as well as development of crystal growth techniques.

In this paper we report the results of our crystal growth experiments and some spectroscopic properties for two Cr^{4+}-doped crystals - Ca_2GeO_4 and Li_2MgSiO_4.

As known the tunable laser operation of Cr^{4+}:Ca_2GeO_4 has been demonstrated in 1996 by Petričević and other [4]. The crystals used in laser experiments have been grown by pulling technique from flux. There are no complete information related to flux chemical composition and growth parameters of Cr^{4+}:Ca_2GeO_4 in literature. We developed original top-seeding solution growth technique of Cr^{4+}:Ca_2GeO_4 from Li_2MoO_4-based solution. Vertical muffle furnace and large Pt-crucible (10x10 cm) were used in the process. All experiments were carried out in air atmosphere.

Well shaped by natural facets, high quality crystals of Cr^{4+}:Ca_2GeO_4 with the size up to 50x25 mm (100 g) have been grown by this technique. Typical crystal is shown in Figure 1.

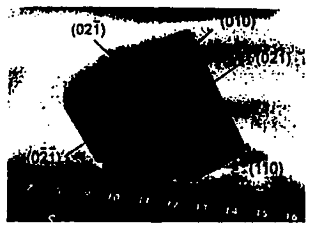

Fig.1. Photograph of Ca_2GeO_4 single crystal growth from Li_2MoO_4-based solution

Preliminary experiments have shown that crystals of Li_2MgSiO_4 can be grown by flux methods. The single crystals of Li_2MgSiO_4 grown from Li_2MoO_4-based solution were plate-like in form 8 mm across and 2 mm thick. Further crystal growth experiments are currently being performed on this material in our laboratory.

The absorption spectra of Cr^{4+}:Ca_2GeO_4 for three different crystal orientations, presented in Figure 2, show features that are strikingly similar to those observed in the absorption spectra of chromium-doped forsterite and other olivins.

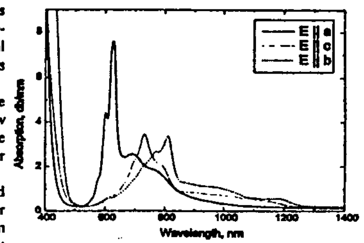

Fig.2 Polarized absorption spectra of Cr^{4+}:Ca_2GeO_4 for three different crystal orientation

The emission spectra of Cr^{4+}:Ca_2GeO_4 and Li_2MgSiO_4 were measured for 514 and 528.5 nm argon laser excitation at room temperature and at liquid nitrogen temperature. Also the luminescence decay measurements at 1.06 μm excitation are presented.

References

1. V. Petričević, S.K. Gayen, R.R. Alfano, K. Yamagishi, H. Anzai, Y. Yamaguchi, Appl. Phys. Lett. 52, 1040 (1988).
2. N.I. Borodin, V.A. Zhytnyuk, A.G. Okhrimchuk, and A.V. Shestakov, "Oscillation of a $Y_3Al_5O_{12}$:Cr^{4+} laser in wavelength region of 1.34 - 1.6 μm", Izv. Akad Nauk SSSR Ser. Fiz. 54, 1500 - 1506 (1990).
3. V. Petričević, S.K. Gayen, R.R. Alfano, Appl. Phys. Lett. 53, 2590 (1988).
4. V. Petričević, A.B. Bykov, J.M. Evans, R.R. Alfano, Opt. Lett. 21, 1750 (1996).

ThV39 MAGNETIC NANOSTRUCTURES PRODUCED BY INTERFERENCE SHORT-PULSED (~ 1 ns) UV IRRADIATION OF THIN-FILM MIXTURES

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Magnetic nanostructures are of fundamental and technological interest[1]. We study the magnetic nanostructure formation under direct irradiation of thin-film (10-15 nm) Fe-Cr and Fe(Co)-C mixtures by interfering laser beams with varying duration (down to 2 ns). A XeCl excimer laser with an output power up to 100 mJ was employed in these experiments. The pulse duration shortening has been obtained by means of a SMBS compression technique[2]. As a result, we have fabricated the gratings of nanoscale (~ 100 nm) (ferro)magnetic stripes. The electronmicroscopic data indicated that the stripes appear via decomposition in interference maxima. The observed coercivity of the gratings (up to 1000 Oe) in combination with small film thickness and high enough magnetization of the stripes allow us to consider the samples under study as a material for magnetic data storage with an ultra-high density. The report presents our nanostructure investigations by various techniques such as magnetic force microscopy, magnetic resonance and magnetooptics.

This work was supported by the RFFI Grant (97-02-16103) and by the National program on Physics of Solid State Nanostructures (1-088/4).

[1]D.D.Awschalom, and D.P.DiVincenzo, Phys.Today 4, 43(1995)
[2]C.B.Dane, W.A.Neumann, L.A.Hackel, *IEEE* J.Quant.Electron. 30, 1907(1994)

ELECTROINDUCED SECOND HARMONIC GENERATION ON SURFACE OF NONEQUILIBRIUM SEMICONDUCTOR: INFLUENCE OF PHOTOSTIMULATED ELECTRONIC PROCESSES

ThV40

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We studied the influence of 10-ns pulses at 25-50-Hz repetition rates from YAG:Nd laser (λ=1064 nm; 10^{10} W/m^2) on silicon. We investigated the spacial transformation of the photostimulated plasma in silicon and its influence on the reflected second harmonic generation. Cases of Gaussian and homogeneous transversal intensity distributions were considered. The theory was based on Fermi quasi-levels approach and on the solution of the set of continuity equations.

It turns out, that in treated case one can neglect the recombination (including Auger-recombination) during pulse.

It is shown, that in less then 1 ns from the pulse beginning the surface space charge region becomes thinner then λ. Then theory of second harmonic generation and nonlinear electroreflection is simplified [1].

It is found, that due to difference of diffusion velocities of electrons and holes from lighted space the transversal potential difference arises reaching some hundreds of millivolts towards the end of a pulse.

Obtained results enable the correct interpretation of findings of nonlinear optical surface diagnostics.

1. I.M.Baranova, K.N.Evtyukhov. Second-harmonic generation and nonlinear reflection on the surface of class m3m semiconductor crystals. Quantum electronics. 27(4). 336-340. (1997).

18:30-20:00 **BEIGE HALL**

ThW - Interference Phenomena in Atomic Systems

ThW1

Coherent Population Trapping in A Resonance Elliptically Polarized Field: Symmetry of Dark States

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Firstly, the problem on the coherent population trapping (CPT) effect in a resonance elliptically polarized field had been stated and solved in the general form in refs.[1] In these works the dark states had been found in the specific coordinate systems. However, in a number of applications, especially, in problems deal with the time-space non-uniformity of a field polarization vector $\mathbf{e}(\mathbf{r}, t)$ (such as laser cooling in a field with a polarization gradient, adiabatic momentum transfer and so on) we need know an explicit invariant form of CPT-states as functions of $\mathbf{e}$. Previously this problem had been solved for two simplest cases of $j_g = 1 \to j_e = 0$ and $j_g = 1 \to j_e = 1$ transitions, where j_g and j_e are the total angular momenta of the ground and excited states [2].

In the present paper an explicit invariant form of dark states is found for all CPT transitions:

1. $j_g = j \to j_e = j$ *(j is an integer) transitions.* The dark state Ψ_j^{NC} is unique and is written in terms of the multiple tensor product of the rank j constructed by the unitary complex polarization vector $\mathbf{e}$:

$$\Psi_j^{NC} = A\{\ldots\{\{\mathbf{e}\otimes\mathbf{e}\}_2\otimes\mathbf{e}\}_3\ldots\otimes\mathbf{e}\}_j\,, \quad (1$$

where A is the normalization constant.

2. $j_g = j \to j_e = j-1$ *transitions.* There are two dark states, which are constructed in the same way as (1) by the circular vectors $\mathbf{a}_1$ and $\mathbf{a}_2$:

$$\mathbf{a}_{1,2} = \frac{\pm i\sqrt{(\mathbf{e}\cdot\mathbf{e})}\,[\mathbf{e}\times\mathbf{e}^*] + [\mathbf{e}\times[\mathbf{e}\times\mathbf{e}^*]]}{\sqrt{1+|\mathbf{e}\cdot\mathbf{e}|}\sqrt{1-|\mathbf{e}\cdot\mathbf{e}|^2}}$$

1. V.S.Smirnov, A.M.Tumaikin and V.I.Yudin, Sov. Phys. JETP, 69, 913 (1989)
A.M.Tumaikin and V.I.Yudin, Sov. Phys. JETP, 71, 43 (1990).
2. M.A.Ol'shanii and V.G.Minogin, Opt. Comm., 89, 393 (1992).

ThW2

Experiments on atomic coherence in alkali atoms

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We present a review of our recent theoretical and experimental work at TAMU and NIST on atomic coherence effects in alkali atoms.

In particular, the work on lasers without inversion includes the first demonstration of noninversion laser oscillator [1] in Rb atomic vapor. The origin of the lasing is studied in subsequent experiments on non-inversion amplification in cold, trapped Rb atoms. Furthermore, the main problems and limitations for the realization of frequency up-conversion via lasing without inversion are pointed out and the recent experimental progress toward realization of frequency up-conversion is discussed.

We also present a proof-of-principle experiment demonstrating a resonant enhancement of the index of refraction accompanied by vanishing absorption in a cell containing a coherently prepared Rb vapor [2]. The results of this experiment are in good agreement with detailed theoretical predictions. We will discuss the possibilities of extending these studies into a domain of dense media, where resonant susceptibility is comparable to unity.

Finally, we describe and demonstrate an efficient process of mirrorless parametric oscillation in Raman-like, near-resonant systems driven by counter-propagating fields. Oscillation typically occurs on both Stokes and anti-Stokes components at frequencies which are very close to that of a two-photon Raman transition. We show that this process can be viewed as a spontaneous formation of coherence grating.

[1] A. S. Zibrov, M. D. Lukin, D. E. Nikonov, L. W. Hollberg, M. O. Scully, V. L. Velichansky and H. G.Robinson, Phys.Rev.Lett. **75**, (1995), 1499

[2] A. S. Zibrov, M. D. Lukin, L. Hollberg, D. E. Nikonov, M. O. Scully, H. G.Robinson, and V. L. Velichansky, Phys.Rev.Lett. **76**, 3935,(1996)

ThW3

About possibility of inversionless amplification at nuclear transitions in gamma-ray range

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The phenomenon of amplification without inversion has been widely studied for the last ten years (see for a review [1]). Very recently the first lasers without inversion have been realized experimentally [2]. It seems natural to apply a concept of inversionless amplification to gamma-ray range where it is hard to achieve population inversion at operating nuclear transition.

The main task of this paper is to verify a possibility of AWI in gamma-ray due to coherent optical driving of atomic transition. In the absence of interaction between electron and nuclear degrees of the freedom the structure of atomic sublevels is exactly the same both for the ground and excited states of the nucleus. Coherent driving of electron transitions in this case certainly does not affect nuclear polarization. However an interaction between nuclear and electron degrees of the freedom can make the structure of atomic sublevels for excited and ground nuclear states essentially different, for instance, due to hyperfine splitting or isomeric shift.

We show that under condition that either hyperfine splitting or isomer shift exceeds Rabi frequency for driving field, the last one is larger than relaxation rate at the optical transition which in turn is larger than relaxation rate at the gamma-ray nuclear transition coherent optical driving leads to suppression of gamma-ray absorption and may provide AWI. By tuning of driving field to resonance with a couple of sublevels of either ground or excited nuclear state the close analogues of basic optical schemes of AWI (so called h, p and ladder schemes [3]) can be realized in gamma-ray range. With further increase of Rabi frequency AWI becomes impossible due to the fact that large Stark splitting restores the symmetry of sublevels structure for the ground and excited nuclear states. For each of this scheme we study numerically dependence of inversionless gain on pumping parameter, Rabi frequency and detuning and find that under the favorable conditions amplification can occur even when only 1% of atoms is pumped into the excited nuclear state.

1. O.Kocharovskaya, Phys.Rep., 219 (1992) 175;
O.Kocharovskaya, Hyperfine interactions, 107 (1997) 187.
2. A.S. Zibrov, et. al., Phys. Rev. Lett., 75 (1995) 1499.
3. O.Kocharovskaya et. al., Phys. Rev. A, 45 (1992) 1997.

ThW4

Amplification without inversion based on field-dependentrelaxation in strongly driven three-level atoms

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Up to now most of the theoretical models of amplification without inversion (AWI) have been investigated on the basis of the traditional master equations with atomic relaxation rates not dependent on external laser fields.

Modification of the relaxation rates due to coherent driving can certainly influence AWI conditions. The degree of such influence depends on the properties of reservoir as well as intensity and detuning of the driving field.

In this paper we analyze the conditions of inversionless amplification for resonant bichromatic field in three-level atoms with the splitted ground state driven by the resonant coherent field and coupled to the frequency-dependent reservoir. The density of modes of this reservoir is supposed to be sharply changed on the scale of driving field Rabi frequency what allows for population of only one of two dressed states. We show that in this case amplification of bichromatic field tuned to the resonance with an inverted dressed transitions can occur without inversion in bare states basis. Moreover inversionless gain for the normal bichromatic wave is defined by the sum of partial gains for each component of bichromatic field in the absence of the other one.

This last result is due to the fact that population of one of two dressed states in the bare atomic basis is equivalent to excitation of the maximal atomic coherence between sublevels providing strong parametric coupling between components of the bichromatic field which would be impossible in case frequency independent reservoir. Hence modification of relaxation rates due to the strong driving provides novel effective mechanism of inversionless amplification.

ThW5

Quasi-dark Resonances: Optical Response Induced by Coherently Altered Quantum Superpositions

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The phenomenon of "dark resonances" or coherent population trapping is by now a well known concept in quantum optics and laser spectroscopy. It is a basis for such effects as electromagnetically induced transparency (EIT) and its applications to nonlinear optics, lasing without inversion and resonant enhancement of refractive index, adiabatic population transfer, sub-recoil laser cooling and atom interferometry.

As a general rule, any incoherent perturbation acting on a "dark state" leads to a partial loss of coherence resulting e.g. in increased absorption, which is usually undesirable. In the present paper we demonstrate that a new and qualitatively different behavior of the optical response occurs when the decoupled quantum superposition state is perturbed in a *coherent* way. In particular, we show that in *four-state systems, in which the original dark state is coupled by some coherent* mechanism to another metastable state, very narrow, high-contrast spectral features emerge, which we term "quasi-dark resonances". The coherent perturbation inducing such a resonance can result, for example, from a microwave field driving a magnetic dipole transition, a two-photon transition via an auxiliary state, a static field or from a non-adiabatic coupling mechanism in time-dependent laser fields.

We show that by adjusting the coherent perturbation these new resonances can be made either absorptive or transparent and their properties such as width and position can be manipulated as well. Furthermore a very weak incoherent excitation of the atoms can be sufficient to turn the absorption at these narrow resonances into optical gain. Such "engineered" atomic responses could be of interest for high-resolution spectroscopy as well as for an enhancement of optical activity in dense media.

PROPAGATION OF GAUSSIAN PULSES UNDER CONDITIONS OF ADIABATIC POPULATION TRANSFER

ThW6

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SUMMARY

In this paper we study the propagation of two partially overlapping gaussian pulses $E_{1,2}(t)$ under conditions of adiabatic population transfer (APT) [1] in a medium of three-level atoms with the energy of states $W_0 < W_2 < W_1$. The atoms interact first with the driving (Stokes) laser $E_2(t)$, which couples the levels $|1>$ and $|2>$, and than with the pump laser $E_1(t)$. The intermediate level $|1>$ is one-photon resonant with both laser pulses. Our theoretical model consists of the coupled density matrix-Maxwell equations, which describe the temporal and spatial evolution of atomic states and two laser pulses. In the numerical calculation we choose $\gamma_{1,2}T = 0.01$, $\gamma_3 T = 0.0001$, $\gamma_{1,2}$ being the decay rates of excited state $|1>$ to $|0>$ and $|2>$, respectively, γ_3 is the decay rate of metastable state $|2>$.

We find that pulses can propagate with practically constant amplitudes in a medium with length as high as the linear absorption length (Fiq.1). However, the front edge of the probe pulse is absorbed and the one of the coupling laser is amplified. Absorbed energy of probe laser is used for the adiabatic preparation of atomic system in the state $|2>$. The calculations also show that APT creates practically full inversion on the dipole-forbidden transition $|0> - |2>$ along the way of pulses' propagation, i.e the atoms are transfered from state $|0>$ to state $|2>$ without loss because the entire process requires no transitions through state $|1>$. We suggest that this technique can be used for conversion of picosecond laser radiation into the tunable coherent anti-Stokes radiation.

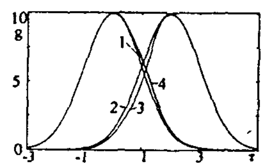

Fig. 1: Temporal profile (τ is the time in units of the pulse duration T) of the normalized Rabi frequencies for pump g_1 (2,3) and Stokes g_2 (1,4) pulses at various depths of penetration L (L is the length in units of the pump absorption length) under simultaneous one- and two-photon resonances. $1,2 - L = 0$; $3,4 - L = 5000$.

1. E.Arimondo, Progress in Optics **XXXV**, 257 (1996).

EFFICIENT NONLINEAR FREQUENCY MIXING IN CW REGIME USING COHERENT POPULATION TRAPPING

ThW7

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SUMMARY

It is well known that the coherent population trapping (CPT) leads to electromagnetically induced transparency [1], while at the same time large coherence on a dipole-forbidden (Raman) transition may be created [2,3]. Thus, using CPT one may combine the minimum of absorption with maximum of nonlinear polarization responsible for frequency conversion, and, at the same time, with improvements in phase-matching and increasing of a medium density. Here, in contrast to [3], we investigate the processes of resonance four-wave mixing $\omega_4 = \omega_1 - \omega_2 + \omega_3$ of cw laser radiations under both single- and two-photon resonances in conditions of CPT. We assume that the fundamental fields at frequencies $\omega_{1,2}$ are strong and their frequencies are resonant to corresponding transitions while the others are weak and are off-resonant. For numerical analysis and illustrations the characteristics of transitions $6S - 6P - 5D - 6\,^1P^0 - 6S$ of Ba atom are used.

We calculated that in atomic Ba vapor nonlinear polarization can be the same as linear one or higher. This is accomplished by using CPT to prepare a near-maximal atomic coherence on a Raman transition $6S - 5D$. The preparation of a inhomogeneously broadened atomic sample in the coherent superposition of states may be achieved using large Rabi frequency, so that nonresonant atoms also are pumped into the coherent superposition too.

It is shown that efficient nonlinear generation with quantum efficiency as high as several tens percent using the CPT is possible. The required input radiation intensities are $\sim 100\ W/cm^2$. We emphasize that some restrictions are applied. Coherence properties are important in CPT concept, therefore, single-mode cw lasers with negligible phase fluctuations are needed.

1. Agap'ev B.D., Gornyi M.B., Matisov B.G., Rozhdestvenskii Yu.V. Uspekhi Fis. Nauk. v.163, 1, (1993).

2. Arkhipkin V.G., Myslivets S.A. Kvant. Elektr., v.22, 933, (1995).

3. Maneesh Jain, Hui Xia, Yin G.Y., Harris S.E. Phys.Rev.Lett. v.77, 4326, 1996.

ThW8

RADIANCE AMPLIFICATION WITHOUT INVERSION

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It was shown on the basis of the detail analysis of the laws of statistical physics and optics, that these laws do not forbid the increase of the radiance and radiation temperature, but do not predict specific conditions of such an increase. The radiance and radiation temperature non-increase requirements can be violated outside the limits of the geometrical optics approximation, even in non-inversion medium. Of course, there are no reasons to treat the induced radiation as an unique optical process of radiance increase.

The radiance of incoherent radiation is proportional to the number of photons per mode. It means, that the processes of the mode occupation should be more effective than the processes leading to the decrease of the mode occupation number, if one needs to increase the radiance. Thus the radiance increase is possible in nonequilibrium processes only. So, the processes should be nonreversible. It means obviously, that the radiance increase can take place being accompanied by the total entropy increase only.

The suitable example of the possible process of the radiance increase is the isotropic luminescence. This process satisfies the requirement of nonreversibility (the entropy increase) and it is impossible to describe it in frames of the beam approach. By solving the equation of the radiance transfer, quantitative conditions of the increase of radiance and radiation temperature in non-inversion media are formulated.

ThW9

ELECTROMAGNETICALLY INDUCED TRANSPARENCY AND ABSORPTION IN A TWO-LEVEL SYSTEM IN Rb ATOMS

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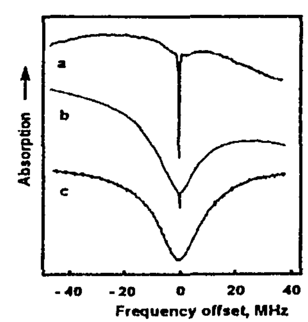
Coherent effects have attracted considerable attention in recent years. In most cases investigations of coherent population trapping (CPT) were performed on alkaline atoms when both ground state hyperfine levels are involved in the interaction with radiation [1].
We present the experimental investigation of spectral properties of a degenerate two-level coherently prepared atomic medium. The experiment was done on the Rb D_1 and D_2 lines. The response of Rb vapor to the presence of bichromatic laser field with variable frequency offset was examined. The absorption of Rb vapor depends on correlation of total angular momentum of ground and excited states coupled by light (F and F', respectively).
Fig.1 shows the absorption as a function of frequency offset on ^{87}Rb D_1 line when optical field is tuned to the transition F=2-F'=1 (a), F=2-F'=2 (b) and F=1-F'=2 (c). Narrow feature on the top of saturated absorption resonances due to CPT on Zeeman sublevels (Fig.1a,b) and its absence (Fig.1c) are in agreement with the theory [2].



However, on the Rb D_2 line the sign of narrow resonance depends on which ground state hyperfine level the optical field is tuned. The first experimental evidence of an electromagnetically induced absorption due to Zeeman coherence is reported. The influence of external magnetic field, polarization and intensity of applied optical fields on the sub-natural-width absorption resonances has been examined.

[1]. E.Arimondo, Progress in Optics, v.XXXV, pp.257-354 (1996).
[2]. V.S.Smirnov, A.M.Tumaikin, V.I.Yudin, Sov.Phys.JETP, v.69, 913 (1989).

ThW10

Interference of Discrete and Continuos Quantum Pathways in Strong Laser Fields at Doppler Broadened Transitions

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Potentials of laser-induced continuum structures (LICS) were considered in [1]. Experimental evidence was given in [2]. The paper is aimed at investigation of the features of such structures resulting from the effects of several applied strong fields and Doppler broadening of the coupled transitions.

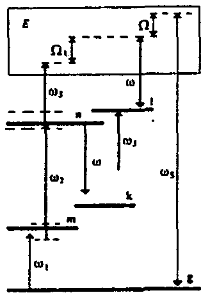

Fig.1

Radiations at ω_1 and ω_S are weak, the others are strong (Fig.1). Radiation at ω_S is either frequency-mixing generated ($\omega_S = \omega_1 + \omega_2 + \omega_3$) or probe one. An auxiliary strong field at ω is applied in order to manipulate by one of the LICS and as a consequence - by the discrete spectra. Solution of Maxwell's and density-matrix equations as well as numerical analysis are used to analize absorption spectra and to demonstrate potential enhancements in output of nonlinear-optical short-wavelengths generation. Fig.2 shows possible dependence of quantum efficiency of conversion from ω_1 to ω_S η_q, determined by appearance of nonlinear interference processes both in nonlinear polarization and in absorption indices, on optical density of the medium and on shifts between two LICS, induced by the strong fields at ω and ω_3.

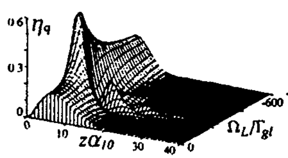

Fig.2

Coupling Rabi frequency of the auxiliary field is about 10, for the rest strong fields - about 1, $\omega_1 - \omega_{mg} = 0$, $\omega_2 - \omega_{nm}$ is about hundred (all scaled to homogeneous linewidths), $\alpha_{01}z$ is unperturbed optical density at $\omega_1 = \omega_{mg}$, Γ_{lg} is homogeneous linewidth. Absorption at ω_1 dominates over that at ω_S.

1. Yu.I.Heller, A.K.Popov, Phys.Lett., **50A**, 453 (1976); *Laser Induction of Nonlinear Resonances in Continuous Spectra* , Novosibirsk, Nauka, 1981(in Russ.) [Engl.transl.: Journ. Sov. Laser Research, **6**, No 1-2, Jan.-Feb., 1985, Plenum, c/b Consultants Bureau, NY, USA]; P.L.Knight, M.A.Lander, B.J.Dalton, Phys. Reports, Vol. 190, No 2, 2, (1990).

2. Yu.I.Heller, *et al.*, Phys.Lett., **82 A**, 4 (1981); Cavaliery S., *et al.*, Phys. Rev., **A 47**, 4219 (1993); Faucher O., *et al.*, Phys. Rev. Lett., **70**, 3004 (1993).

ThW11

Fluorescence and Absorption Properties of a Driven Λ-System

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Spectroscopy and quantum theory of three-level atomic systems beeing a fundamental field of laser and atomic physics give also a rise to a whole bunch of applications, namely, development of new optical standards, cooling of atoms, lasing without inversion, etc. [1]. In this work, we consider both resonance fluorescence and absorption properties of a three-level system in Λ-configuration driven by two laser fields at the Raman resonance condition. It was shown previously that the strongest components in the fluorescence spectrum of the Λ-system are two Mollow-type structures centered at the transition frequencies ω_{13} and ω_{23} (numbers 1 and 2 denote ground levels of the system and 3—an excited state). This is a correct result only in the rotating wave approximation (RWA), whereas beyond the RWA non-resonant interactions, which are of order of g_Λ/ω_{12} (g_Λ is the field coupling constant), come into the play and modify the spectrum. These modifications result into two additional spectral structures centered at the four-photon frequencies $2\omega_{13} - \omega_{23}$, $2\omega_{23} - \omega_{13}$ and consisted of a coherent and two broadened lines each (see [3] for further details).

Our calculations presented here are focused on analytical results describing fluorescence and absorption properties of the Λ-system. For the case of saturating field ($g_\Lambda \gg \gamma$, where γ is the typical radiation relaxation rate of the system) we derive new analytical expressions for fluorescence and absorption spectra for unequal field strengths and non-zero detunings. We also considered a case when one of the driving fields is much stronger than another one and the resulting spectra must be similar to the spectra of a two-level atom.

An accent has been made on non-Lorentzian sign-changing dispersive part of the spectrum. This contribution appears due to the specific character of the quantum correlation functions of the Λ-system and being of order $(\gamma + \delta)/g_\Lambda$ (where δ is the two-photon detuning) could play an important role in high-precision spectroscopy of dark resonances. We analyzed this contribution analytically and compared the results with numerical calculations.

References

1. E. Arimondo, in *Progress in Optics*, edited by E. Wolf (Elsevier, Amsterdam, 1996), Vol. 35, p. 257.
2. L. M. Nardicci, M. O. Scully, G.-L. Oppo et al., Phys. Rev. **A 42**, 1630 (1990).
3. B. A. Grishanin, V. N. Zadkov, D. Meschede, JETP, **113**, 144 (1998).

ThW12 Magnetically Induced Invertionless Amplification.

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Coherence effects in atomic systems provide various phenomena. One of them is gain in atomic medium, which does not exhibit population inversion. In this work we present a new scheme of amplification without inversion.

We theoretically consider a probe field propagation in a medium of two-level atoms with equal momenta of the ground and excited states $F_g = F_e = 1/2$. The atoms are pumped by a circular popularized optical field, which is taken to be a Gaussian-Markovian random process with a finite bandwidth of the noise. A static magnetic field is directed orthogonal to the pumping field propagation. In the absence of the magnetic field the pumping induces the atomic orientation along the pumping field propagation. When the magnetic field is applied, the atomic magnetic moment starts to precess around the magnetic field. This lead to creation of the coherence between sublevels of the ground and excited states. Such medium does not exhibit population inversion between the ground and excited states or between any sublevels of the ground and exicted states. Nevertheless one of the normal waves can amplify in the center of line, when a probe field propagates in the direction orthogonal to the pumping field. Amplification without inversion occurs in the case of the Larmor frequency and the pumping rate are of the order of the pumping linewidth, which was taken much broader than the transition width. Inversionless amplification in this case can be interpreted as coherence effect induced by the magnetic field.

ThW13 Quantum Interference in Light Propagation through a Medium of Double-Λ atoms

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Theoretical investigations of the c.w. laser radiation propagation through a medium of atoms with double-Λ configuration of levels are presented. Interaction of a four-frequency laser radiation with double-Λ atoms provides a very reach spectrum of phenomena based on atomic coherence. This is due to the manifold quantum interference of the excitation channels in such a system. For example, coherent population trapping occurs if following conditions are satisfied: (1) four-photon resonance; (2) relative phase of the light fields $\Phi = \varphi_1 - \varphi_2 - \varphi_3 + \varphi_4 = 2\pi n$; (3) light intensities are in relation $I_1/I_3 = I_2/I_4$, where indexes 1,2 and 3,4 are related to the fields exciting first and second Λ system, respectively. Under these conditions, all atoms are pumped into the dark state superposition, and the medium becomes transparent to the laser light. The medium is again opaque if, e.g., $\Phi = \pi$. Thus, one can manipulate absorptive and dispersive properties of the medium changing only phases of the light waves. On the other hand, such a medium may be used for manipulation of the light properties. If the phase and intensities deviate from conditions (2) and (3), then the light fields, while propagating through the double-Λ medium, are changed until their parameters do satisfy (2) and (3). Thus, laser intensity and phase matching occurs. We note also the possibility of amplification of one of the laser waves in expense of the others, and frequency generation (four-wave mixing process) enhanced by quantum interference.

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ThW14

MODE LOCKING VIA QUANTUM COHERENCE

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A major part of cw lasers can not be used as ultrashort pulse sources because of their narrow linewidth — all known mode-locking techniques fail to generate pulses shorter than the inverse spectral linewidth. Going beyond the traditional view of a laser medium as simply a two-level system and utilizing the coherent effects in three (or more) level configurations we can easily overcome the inverse linewidth limit for the pulse duration. Indeed, applying a strong field on the coupled transition of 3-level medium the properties (dipole moment and decay rates) of the lasing transition change crucially. Increase in the intensity of the drive field leads to substantial linewidth broadening, that results in its turn in generating more shorter pulses.

Based on this simple picture recently we have proposed a new type of mode locking with threelevel gain media. For the first time we have demonstrated the possibility of actively modelocked LWI generating pulses, which are considerably (by the orders of magnitude) shorter than those in conventional laser systems. Also we have shown that the mode locking technique based on the coherence effects in multilevel media can be successfully applied to all types of lasers: lasers with inversion, (near-resonant) Raman lasers, lasers without inversion, and to various types of gain media: gaseous, dyes, solid-state, semiconductor etc. The coherently driven three-level medium is not limited in use to as a laser amplifier only. It could also be of use as a saturable broadband intracavity absorber, pulse compressor etc. This list is far from completion. The outlook for the concept of the coherent control of the optical material properties by light is rather optimistic, particularly in optoelectronics applications.

ThW15

EIT and Amplification of EM-Wave in Photonic Band Gap Materials

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There is a growing interest in the studies of the propagation of electromagnetic (EM) waves in periodic dielectric structures in the last decade. This interest is rigidly bind to an effect of photonic band gap appearance in these structures. It is known, that in periodic dielectrical materials a stop band with zero density of states for EM modes propagation in given direction is forming. This phenomenon has been demonstrated both theoretically and experimentally.

Usually properties of photonic materials are investigated for a weak EM fields neglecting nonlinear properties of crystals. Meanwhile, photonic band gap structures are often fabricated from dielectric materials with large nonlinearities, which can significantly change heterostructure properties in the presence of EM fields. It is interesting to determine new features of these phenomena appearing due to presence of band gap.

In this paper, we consider nonlinear EM wave propagation in the forbidden frequency region and a possibility of control of a such gap via interaction with strong EM field. For the model of medium we use material doped by Λ tree-level atoms. The gap arises as a result of spatial modulation of density of these dopants. For the sake of simplicity, we limit ourselves to an one-dimensional case.

We analyze the dispersion relations for waves in nonlinear photonic material in the presence of strong driving field including both Stokes and anti-Stokes waves. We find the electromagnetically induced transparency in such material and possibility of amplification for EM waves in band gap. An application of proposed phenomena is Q-switching, filtering and others.

ThW16

Nature of Quantum Interference in Lasing Without Inversion

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It was first pointed out by Javan [1] that certain effects in a three-level system cannot be predicted by considering the population difference alone. The possibility of lasers without population inversion was noted many years ago, it was, however, away from the central attention at that time and did not lead to any attempt of experimental realization. The current idea of lasing without inversion was proposed in the late 80's independently by several authors[2,3,4] and has been received considerable attentions. Particular attentions have been paid to the two among the many models of active mediums, namely Λ-type and V-type. However, as is pointed out by Grynberg, Pinard, and Mandel[5], the relations between these effects in various models of atomic system have seldom been clarified.

Describing the physical mechanism in terms of quantum interference needs quantum mechanical two paths and it is provided by the coherent driving field via Autler-Townes doublet. In addition, the pattern of quantum interference is governed by the spontaneous emission occurring in the driving transitions. We clarify the role of spontaneous emission processes on the atomic coherence effects and emphasize the importance of the irreversible dissipative processes. In particulr, the quantum beat-type interference is prepared "by" those spontaneous emission processes. On the other hand, the Fano-type interference is "through" those spontaneous emissions.

[1] A. Javan, Phys. Rev. **107**, 1579 (1957)

[2] O. Kocharovskaya and Ya. I. Khanin, Pis'ma Zh. Eksp. Theo. Fiz. **48**, 581 (1989) [JETP Lett. 48, 630 (1989)].

[3] S. E. Harris, Phys. Rev. Lett. **62**, 1033 (1989).

[4] M. Scully, S.-Y. Zhu, and A. Gavrielides, Phys. Rev. Lett. **62**, 2813 (1989).

[5] G. Grynberg, M. Pinard, and P. Mandel, Phys. Rev. A **54**, 776 (1996).

ThW17

Resonant Raman Amplification of Ultrashort Pulses in a V-type Medium

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Creation of new sources of coherent UV and X-ray radiation is a challenging task of applied optics. During the last few years, alternative mechanisms of coherent light amplification, which do not require population inversion on lasing transition, attracted considerable attention. However, most of this research has been done in the continuous-wave regime, while operation with short pulses has the principal practical advantages.

In the present paper we will study coherent pulse amplification in the V-type medium pumped by short laser pulse. Duration of the pump pulse is supposed to be shorter than all relaxation times in the medium. Both pump and probe pulses are tuned close to corresponding atomic resonance frequencies. Atoms constituting the medium are not supposed to be prepared in the coherent superposition of bare atomic states. We will show analytically and numerically that, in the system under consideration, linear *Gain Without Inversion* is impossible. At the same time, resonant character of the atom-field interaction has two practically important consequences: In the presence of Raman inversion, the probe pulse can experience strong resonantly enhanced two-photon gain, not accompanied by fast absorption of the pump pulse. Furthermore, the system yields a "pulse-locking", i.e. the probe and pump pulses propagate together, with the same group velocity, and without substantial change of shape while propagating. Due to that, the effective gain for the probe pulse is higher than in conventional, far off-resonant Raman laser schemes, and the threshold power of the pump source can be considerably reduced compared to those schemes.

In the case of weak probe pulse it is possible to study the system analytically. In this limit we will derive the formula for the probe energy gain; this formula is valid for arbitrary shape of the pulses. When amplified probe pulse acquires appreciable value, analytical study becomes problematic, and we study this regime numerically.

Various aspects of frequency up- and down-conversion using resonant two-photon amplification, and the physics behind it, will be discussed.

ThW18

Sub-Doppler Resonances of Absorption and Transparency Induced by Strong Radiations in Ladder Systems

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Potentials of elimination of Doppler broadening in quantum systems, coherently driven by strong field, have recently gained increasing interest [1]. The effect was predicted in [2a] and observed in [2b]. The features of the effect in two strong fields were investigated in [2c]. We show further possibilities to extend conditions to realize and to manipulate such sub-Doppler structures in three-photon schemes.

An energy level model *0-1-2-3*, coupled to the three quasiresonant fields $E_{1,2,3}$ at $\omega_1 \approx \omega_{10}$, $\omega_2 \approx \omega_{21}$, $\omega_3 \approx \omega_{32}$ is considered. At $E_3 = 0$ and at one-photon detunings much greater than transition Doppler-widths, two-photon absorption linewidth of a probe field at ω_1 was shown to be determined by the factor $\Delta\omega_D \approx 2|\mathbf{k}_1 - M\mathbf{k}_2|u$ [2a], where $\mathbf{k}_{1,2}$ are wave vectors, u - thermal velocity. Power dependent frequency-correlation factor M is derivative of the resonance value of ω_1 over ω_2. For the weak fields $M = 1$, indicating complete two-photon correlation. With growth of the E_2, M - factor may change from 1 down to 1/2. That provides feasibilities of drastic reduction of the resonance width even when $\omega_1 < \omega_2 < 2\omega_1$.

With the aid of equations derived in [3] we show, that even if that requirement can not be fulfilled, the suppression of Doppler broadening may be achieved with the aid of third strong field at ω_3, quasiresonant to the adjacent ladder or folded transition. Numerical analysis for the models, relevant to the alkali atoms is presented. Dependence of the line shape on the intensities, detunings and relative direction of propagation of the coupled waves is investigated.

[1] G.Vemuri et al, Phys. Rev. **A53**, 1060 (1996); **A53**, 2842 (1996); Y.Zhu and T.N.Wasserlauf, Phys. Rev. **A56**, 2842 (1996).

[2] a)T.Ya.Popova et al, JETP, **30**, 243 (1970); A.K.Popov and L.N.Talashkevich, Opt. Commun., **28**, 315 (1979); b) S. Reynaud et al, Phys. Rev. Lett. **42**, 756 (1979); c) A.K.Popov and V.M.Shalaev, Opt. Commun., **35**, 189 (1980); Opt. Spectr., **49**, 617 (1980); Sov.J.Quant. Electr.,**7**, 1362 (1970).

[3] A.K.Popov, Bull. Russ. Acad. Sci., (Physics), **66** (No6), 99 (1996); A.K.Popov et al, JETP, **113** (No1) (1998).

ThW19

Electromagnetic waves propagation in optical media consisting of an ensamble of atoms with cascade scheme of levels governed by cooperative effects.

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We have investigated theoretically the propagation of two coherent resonant electromagnetic waves through an optical medium consisting of an ensemble of atoms with cascade scheme of levels with interatomic distance less than the wave length. We propose that the process of propagation governed by cooperative effects.For the sake of simplicity we neglect the incoherent decay of the upper atomic states arising from interaction with the continuum of vacuum modes. The reason for that simplification is that process governed by cooperative effects much faster then any incoherent decay. We examine the self - consistent set of equations for the atomic density matrix and the slowly varying electric field envelopes for the two pulse components. We describe atomic media by the collective atomic operators and the coherent fields by the boson operators of creation of photons.The initial state of atoms corresponding to t?-? is chosen in the following form: population of the ground state equal to 1 and another states are empty.We have investigated the set of equations describing the propagation of the electromagnetic waves numerically under coherent population trapping (CPT) conditions. So we should point out the main result of the present work:When the two-photon resonance condition is fulfilled, then all atoms tend to be trapped in a coherent dark state, so coherent population arises in a case of cooperative decay. The amplitude of the of the wave decrease by a non-exponential law. The phenomenon considered in the present work allows us to establish coherent transparency in optical media, providing loss-free propagation.

ThW20

COHERENT CONTROL OF POPULATION TRANSFER IN N-LEVEL SYSTEMS: TRAPPED STATES, COUNTERINTUITIVE SOLUTION AND BEYOND

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Stimulated Raman Adiabatic Passage (STIRAP) has proven to be an efficient and robust technique for transferring population in a 3-level system without populating the intermediate state. On the other hand, the studies for the optimal shaping of pulse sequences to control atomic or molecular dynamics have reached a high degree of sophistication, specially since the advent of the use of Optimal Control Theory (OCT). In this contribution we show the connection between the counterintuitive order in STIRAP and the population locking condition of the intermediate levels (trapped states). Moreover we establish a rigorous connection between the theory of Optimal Control and the physics of STIRAP. We demonstrate on the universal plane - { effective Rabi frequency; time delay between pulses } the domains where population transfer using intuitive sequence of the π pulses and counterintuitive pulse sequence of the adiabatic passage have highest efficiency. On the same plots we present how the domains are changed if we demand a restriction on the amount of population in the intermediate levels, and we consider under what circumstances (initial conditions) can OCT methods provide the robust solutions. One of the advantages of control theories is the automated computational procedure they involve. Thus, they open the door to computation of generalized STIRAP schemes in arbitrarily complicated N-level situation. We present a simple qualitative extension of STIRAP for N-level sequentially coupled systems and we show that this scheme is more general and robust than other proposed methods. The new scheme, named Straddling STIRAP, involves the use of pulses linking the intermediate states that are spanning both the Stokes and pump pulses, which are also in counterintuitive order. We demonstrate that this scheme arises naturally from the population locking condition and that it is also a global optimal solution.

ThW21

PHASE-SENCITIVE COHERENT PHENOMENON IN DOUBLE Λ-SYSTEM: RAMAN POPULATION TRANSFER

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At the present time the phenomenon of the coherent population transfer in the atom systems has many applications both in the area of sub-Doppler cooling and for creating of efficient splitter for atom wave packet [ ]. The basic problem for such applications is the efficiency of the coherent population transfer. It was known [ ], that in the case of three-level the efficiency of such transfer is defined the relation between amplitudes of time-delayed laser pulses and the time delay τ: $\Omega\ \tau >> 1$(*), where Ω
are Rabi frequency of laser pulses and we assume the frequency detunings are equal to zero.
In this message it is considered the coherent population transfer in the multilevel atomic system, which are the loop contour of interaction with optical radiation. Using double Λ-system as an example, it has been shown that the efficiency of coherent population transfer is defined of the volume of the phase atom contour. Particularly, for the volume of the phase is equal to zero there is the efficient coherent population transfer from the one of the lower level of double Λ-system to the other one while the coherent population transfer is not observed for the volume of phase is equal to $\pi/2$ (fig.1). Fig.1 shows the population from the one of lower level of double Λ-system for the phase equal to $\pi/2$, when the typical condition (*) for efficient population transfer is valid. We can see that in this case there is no the population transfer since the population does not move from initial populated level to the other one
for time of interaction between atom and light pulses. We are shown also that the typical adiabatic condition which defines the coherent population transfer efficiency, in the case of the system with the loop contour of interaction should be added to the condition on the phase volume of the atom contour.

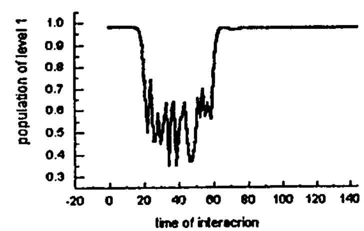

FIG.1 Dependence of the population from the one of the double Λ- system lower states on the time of interactions between atom and laser pulses. Detunings such pulses are equal to zero. The pulse shape is Gaussian with time delay about 10Ω.

REFERENCES

1. E.Korsunsky *Phys.Rev.*, A54, N3, p.R1773, 1996
2. P.D.Featonby et al., Phys.Rev.,

ThW22

ON POSSIBILITY OF THE SELECTIVE PHOTOEXCITATION OF MOLECULES IN DENSE GAS MEDIA

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We consider the molecular quantum Λ- system, which is formed by sublevels $|1\rangle$ and $|2\rangle$ of the ground term and the excited level $|3\rangle$. This Λ- system interacts with two monochromatic waves with frequencies ω_1 and ω_2 close to centers Ω_{31} and Ω_{32} of optical transitions $|1\rangle-|3\rangle$ and $|2\rangle-|3\rangle$ respectively. The fraction of molecules will be trapped in states $|1\rangle$ and $|2\rangle$ of the open Λ- system at the optical pumping under the condition of the Coherent Population Trapping (CPT) [1]

$$|\omega_2-\omega_1-\Omega_{32}+\Omega_{31}|\le W\,, \qquad (1)$$

where the value W is much less than the homogeneous width γ of spectral line of resonance transitions. At CPT the Λ- system is in such superpositional lower state $|NC\rangle$, which does not interact with the radiation [1]: $|NC\rangle = g_2|1\rangle - g_1\exp[i(\omega_2-\omega_1)t]|2\rangle$, where g_j is the Rabi frequency for the transition $|j\rangle-|3\rangle$ ($j=1,2$). Trapped molecules (1) may be then excited by the definite change of values g_1 and g_2 , which causes the transformation of the state $|NC\rangle$.

We carried out theoretical analysis of the photoexcitation of molecules on the basis of the density matrix formalism with due regard of relaxation processes in gas media. It is shown that the high - selective excitation of molecules may be realized by the sharp change of amplitude and phase parameters of pumping waves at their fixed frequencies ω_1 and ω_2. Selectivity of given photoprocesses is determined by the value $W=4\sqrt{(|g_1|^2+|g_2|^2)\Gamma/\gamma}$ (1) at sufficiently small Rabi frequencies $\gamma^2 >> |g_1|^2+|g_2|^2 >> \gamma\Gamma$, where Γ is the relaxation rate of populations and the coherence of states $|1\rangle$ and $|2\rangle$ ($\Gamma << \gamma$). Such photoexcitation may be used in technology of isotope (isomer) separation, photochemistry and molecular biology, especially in cases of comparatively dense media when the selectivity of usual methods of laser action is low because of the large spectral width $\gamma >> W$.

1. Agap'ev B. D., et al. // *Usp.Fiz. Nauk.* 1993. V. 163. P. 1.

ThW23

SUBRECOIL VELOCITY SELECTION OF MOLECULES BY MEANS OF THE STATIONARY OPTICAL PUMPING

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The possibility of selection of slow molecules was shown in theoretical papers [1] by means of the coherent population trapping (CPT) of quantum levels in the case of the stationary optical pumping on a noncyclic transition. Unlike [1], in present work light pressure effects are taken into account .

We consider the spreading of two plane monochromatic counterpropagating light waves (1 and 2) through the rarefied molecular gas. Frequencies ω_1 and ω_2 of these waves are close to centers Ω_{31} and Ω_{32} of optical transitions $|1\rangle-|3\rangle$ and $|2\rangle-|3\rangle$, respectively, between the excited level $|3\rangle$ and sublevels $|1\rangle$ and $|2\rangle$ of the ground molecular term. Quantum - mechanical analysis of change of inside and translatory degrees of freedom of molecules in such light pumping was carried out on the basis of the density matrix formalism.

Due to the CPT at the optical pumping, the fraction of such molecules will remain in the open Λ-system, whose velocity projections v (on the direction of the wave 1) are close to the value v_1 for the state $|1\rangle$ and to the value v_2 for the state $|2\rangle$:

$$|v-v_1|\le W, \qquad |v-v_2|\le W\,, \qquad (1)$$

where $v_1=(\delta_1-\delta_2)(k_1+k_2)^{-1}-0.5(v_{r1}+v_{r2})$, $v_2=(\delta_1-\delta_2)(k_1+k_2)^{-1}+0.5(v_{r1}+v_{r2})$, $k_j=\omega_j/c$, $\delta_j=(\omega_j-\Omega_{3j})$ is the frequency detuning for the wave $j(j=1,2)$, $v_{rj}=\hbar k_j/M$ is the recoil velocity for molecules with the mass M. The value $W(1)$ depends on the saturation parameter p of resonance transitions (with the width 2γ) and the characteristic transit time τ of molecules through the region of the optical pumping ($\gamma\tau << 1$) . For example , $W=2k^{-1}\sqrt{p\gamma/\tau}$ under conditions $|\delta_1|<<\gamma$, $|\delta_2|<<\gamma$, $k_1\approx k_2=k$, $(\gamma\tau)^{-1}<<p<<1$, $kv_r<<\gamma$, where $v_r=\hbar k/M$, ($v_r\le 1cm/s$). Subrecoil velocity selection of molecules is possible when in (1) the width $W<v_r$, that is at the transit time $\tau>4p\gamma(kv_r)^{-2}$.

1. Izmailov A.Ch.// *Laser Physics.* 1994. V. 4. P. 1192 ; *Opt. i Spectrosk.* 1996. V. 81 . P.5.

ThW24

SPATIO-TEMPORAL NONLINEAR DYNAMICS OF COHERENT FIELD IN PERIODIC RESONANT STRUCTURES AND GAIN GRATINGS

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Interest in nonlinear light-matter interaction in distributed feedback structure has considerably grown in the last years[1]. The nonlinear spatio-temporal dynamics of the field in the structures is qualitatively different from that both for the case of linear Bragg diffraction and the nonlinear interaction outside the diffraction condition. It has been predicted earlier[2] that gap soliton of self-induced transparency propagates at the Bragg frequency in discrete resonant structure, which consist of a set of ultrathin layers of two-level atoms.

Here we consider theoretically the short pulse transmission in a resonant one-dimensional Bragg structure with arbitrary periodic modulation of atomic density. This model could be realized, for instance, in experiments with colloidal crystals[3]. We present analytical and numerical solutions of Maxwell-Bloch equations, which describe the spatio-temporal dynamics of formation and propagation of gap solitary waves within the linear forbidden frequency gap band of arbitrary resonant periodic Bragg structure. The velocity and the form of the pulse depends on the profile of atomic density modulation. The pulse propagation in sinusoidal structure is similar to the case of discrete Bragg structure.

We studied also the coherent decay of optically-written sinusoidal gain grating under Bragg condition. Describing this process by numerical solution of coupled-mode Maxwell-Bloch equations we investigated the dependence of the spatio-temporal dynamics of field and inverse population of atoms on frequency shift and initial inverse population. The coherent interaction of incident pulse with the gain grating leads to its amplification and shortening.

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1. F. K. Kneubuehl, *Theories on Distributed-feedback Lasers. Laser Science and Technology* (Ed. by V. S. Letokhov, C. V. Shank, Y. R. Shen and H. Walther), Vol.14, Harwood Academic, Switzerland (1993); J. Feng, F. K. Kneubuehl, *Solitons and Chaos in Periodic Nonlinear Optical Media and Lasers*, Chapter 15 in "Advanced Electromagnetism: Foundations, Theory, Applications", World Scientific Publ. Co., Singapore, (1995).
2. B. I. Mantsyzov, Phys.Rev. A 51, 4939 (1995).
3. W. L. Vos, R. Sprik, A. van Blaaderen, A. Imhof, A. Lagendijk, and G. H. Wegdam, Phys.Rev. B 53, 16231 (1996).

ThW25

Generation of Bell–states and EPR–pairs in the resonance fluorescence of a bichromatically driven four–level atom

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SUMMARY

Strongly correlated photons are the basic requirement for the production of EPR-pairs. Another condition is th presence of different polarization directions in the photon field. Neither condition can be realized in the case of RI from a two level atom.

In this paper we demonstrate the generation of strongly correlated photon pairs in the RF of a bichromaticall driven four-level atom. The four-level atom has two twofold degenerate states where the degeneracy is with respe to the magnetic quantum number $m_j = \pm 1/2$ [1]. As a consequence of the internal structure of the four-lev atom different polarization directions are now possible in the RF. Furthermore, we show that photons with differen polarization directions are entangled. Thus, both basic assumptions, two-photon emission and the possibility different polarizations can be realized in the case of a bichromatically driven four level atom.

The second order correlation function exhibits anti bunching [2] for $\tau = 0$, independently of the interaction param eter ξ. In addition, an interesting parametric dependence of the time-dependent second-order correlation function o the interaction parameter ξ can be observed. As in the case of a bichromatically driven two-level atom, non line two photon emission processes appear for certain values of ξ. Unlike, however, in the two-level case these nonline two photon emission processes exhibit a strong dependence on the polarization direction of the emitted photons i the four level atom case.

We found very strong super bunching in two-photon emission for a pair of σ^+ and σ^- circularly polarized photon in the case of a z polarized bichromatic driving field for small ξ. It is reduced for intermediate values of ξ an increased again at certain values of the interaction parameter. On the other hand, two photon emission processes o a σ^+ σ^+ or a σ^- σ^- photon pair are not possible in the case of a z polarized bichromatic driving field.

For an x polarized bichromatic driving field there arise now strong super bunching effects between σ^+-σ^+ or σ^--σ^- photon-pairs, due to the different polarization state of the driving field, while the σ^+-σ^- or σ^--σ^+ photons ar well separated in time.

A recent paper by Eichmann *et al.* [3] reported on interference experiments using the light scattered from tw single $^{198}Hg^+$ ions in a linear trap. The $^{198}Hg^+$ ions have an internal structure identical to the 4-level atom w are considering in this paper. A similar experimental setup would make the verification of the above results feasib and would even offer further opportunities for quantum computing and quantum information processing. Thes applications require appropriate superpositions of the above EPR- and Bell-states which, in the case of two trappe Hg ions, can be ralized if we drive one of them with an x-polarized field and the other with a z polarized field. I we assume that the two atoms do not scatter at exactly the same time then the arising photon state must be i a superposition of the above two states because it is impossible to know which atom scatters. Perhaps the mos important feature of this system is that we are in the steady-state regime of the atoms and, therefore, the generate two photon states are completely free of decoherence as long as there are no other absorption or scattering processe

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[1] D. Polder and M. F. H. Schuurmans, Phys. Rev. A 14, 1468 (1976).
[2] L. Mandel and E. Wolf, *Optical Coherence and Quantum Optics* (Cambridge University Press, Cambridge, MA, 1995).
[3] U. Eichmann, J. C. Bergquist, J.J. Bollinger, J.M Gillgan, W.M. Itano, D. J. Wineland and M. G. Raizen, Phys. Rev. Lett 70, 2359 (1993).

ThW26

3-D solitons of supertransparency.

Summary

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We investigated experimentally and theoretically the coherent propagation of a pulse through an optically dense (KoL ≥ 60) resonantly absorbing medium. The experimental method is based on the use of a convergent light-beam geometry. The beam focused lens on the exit of the absorbing cell containing Ne. The effects was observed for the first time and was termed supertransparency. Its characteristic features as follow:

1. A pulse propagetes over anomalously long distances exeeding both the known limit for self-induced transparency: KoL ≤ T_2/τ = 3 in our conditions and KoL ≤ 10-15.
2. The propagation of a pulse in our conditions is accompanied by a large shift of its carrier frequency equal ≈ $2\Delta\nu_D$ = 2400 MHz.
3. The frequency shift exists only in the red direction from line center and it is independent of the initial detuning.

These experimental results cannot be explaned on the basis of existing theories. A unified description of suppertransparency is possible on the basis of the diffraction-dispersion compensation mechanism, proposed by the authors. A energy is transferred into the red region of the spectrum with help of that mechanism.

Difraction is the source of phase self-modulation and gives rise to symmetric spreading of the frequencies with respect to the central frequency. Part of the broadened spectrum falls into the region of violet detuning.In that spectrum area the dispersion of the group velocity is positive and therefore these spectral components disperse in time and the violet components of the field absorbed are rapidly.

The part of the spectrum falling within the region of red detuning from the frequency is subject to anomalous dispersion of the group velocity, and the mponents of the field run together in time. The mutual compensation of the elf-modulation and anomalous dispersion of the group velocity produces able conditions for the transfer of the energy stored in the field into red region of the spectrum, as was observed on supertransparency experiments. It explains three earlier mentioned features of the effect.

Having found that the difference between the classical seft-induced transparency experiments and supertransparency experiments is due mainly to the use of light beams which are bounded in the transverse density profile match the transverse profile of the field, as required for stationary propagation of a pulse, is equivalent to the use of a focusing lens in the experiments. Analysis of the transverse dynamics of a three-dimensional self-induced transparency pulse is proves, that it is a natural extension of a self-induced transparency soliton.

1. V.V.Kozlov, E.E.Fradkin, V.S.Egorov and N.M.Reutova JETP. 1996, v.83, s.927-939.

ThW27

KINETIC EQUATION FOR COLLECTIVE OSCILLATIONS OF DIPOLES IN STRONGLY OPTICALLY EXCITED SUBSTANCES

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In spite of advantages achieved in kinetics of dipoles, so far, the mechanism of appearance and evolution of dipole collective coherent oscillations (DCCO), arising under the influence of dipole-dipole interactions (D-DI) in strongly optically excited substances, are insufficiently investigated due to difficulties in accounting multiparticle effects. These difficulties were partially overcome by separating of the main part of the density matrix written for a system of interacting dipoles with the use of simple physical reasoning and following calculations of the rate of dipole density change. In this way the Bloch equation has been derived which is applicable to description of the effects caused by dephasing of dipoles in resonant optics, NMR and ESR.

A new kinetic equation for *partial* densities of dipoles is proposed [1,2]. To derive this equation, we introduce other variables and used such plain physical considerations which allow the contribution of D-DI to the rates of dipole density change to be determined in more detail. Being even more general, than the Bloch equation, the proposed equation describes not only dephasing, but also DCCO which arise under D-DI in strongly optically excited substances. It is shown [3,4], that DCCO initiate a superradiation pulse and cause its oscillatory structure. It is established [1] also that DCCO produce the effect of spectral condensation of radiation, observed in intracavity laser spectroscopy. For the first time in the theory of lasers, the internal laser motion of dipole densities is analyzed taking into account D-DI (in a paper submitted to Zh. Teor. Exp. Phys.).

1.Ivanova A.V., Provotorov B.N. JETP 80(2), p.254 (1995)
2.Ivanova A.V., Provotorov B.N. Chem.Phys.Rep. 14(8), p.1127 (1995)
3.Ivanova A.V., Provotorov B.N. JETP 80(6), p.1024 (1995)
4.Ivanova A.V., Provotorov B.N. Chem.Phys.Rep. 15(5), p.669 (1996)

ThW28

COUPLED PULSES PROPAGATION IN A TWO-COMPONENT MEDIA

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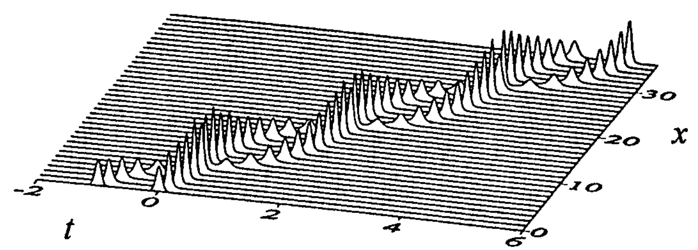
We report the results of the study on coherent pulse propagation in a two-component medium consisting of two species of resonant atoms. As the Raby frequency is proportional to the dipole matrix element of transition ($\Omega \sim d$), we have $\Omega_a < \Omega_b$ as far as $d_a < d_b$. So we call the "a" atoms as slow atoms, and "b" atoms as fast atoms.

It is well known that the ultrashort pulse evolution depends on its area in the coherent mode for both resonantly amplifying and resonantly absorbing media. In the two-component medium the propagating pulse has different area with respect to slow and fast atoms [1]. Therefore the 2π-pulse with respect to the fast atoms will be amplified when the slow atoms are in the excited state and will be absorbed when the slow atoms are in the ground state. We consider the subthreshold regime [1] and show that the regime of coupled pulses propagation can occur in this case. We obtained that two pulses in the two-component medium can be bound in pair and begin to propagate as an unified excitation. The intensity and duration of the coupled pulses oscillate near some mean values.



References

1. A.V.Andreev and P.V.Polevoy, *Journal of Russian Laser Research*, 17, 501 (1996).

ThW29

OPTICAL SCREW-TYPE TRANSPARENCY

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We present a new exact solution of Maxwell-Schrodinger set of equations. This describes propagation of a bichromatic laser pulse through a lambda-type medium where the initial atomic state is prepared in the form of spatially-varying coherent superposition of low-energetic states. The common envelope $E =\sqrt{E_1^2 + E_2^2}$ behaves as a usual 2π hyperbolic secant pulse, but the ratio between the components changes due to coherent Raman scattering so $\mbox{arc tg} \frac {E_2}{E_1} = Gz$, where z is the coordinate, G is the constant determined by both the incident pulse parameters and the initial coherence between the atomic states. Our solution demonstrates a direct connection of electromagnetically induced transparency in adiabatic regime to the self-induced transparency effect. We regard this solitary wave as a screw-type one because its propagation requires matching between incident pulse parameters and initial coherency (the latter can be prepared by means of CW coherent population trapping).

ThW30

PHOTOEFFECT IN BICHROMATIC LASER FIELD: NEW POSSIBILITIES OF NONLINEAR OPTICAL MEASUREMENTS OF SURFACES, THIN FILMS AND HETEROJUNCTIONS PARAMETERS.

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Formulae for photocurrent of extrinsic photoeffect in bichromatic field at ω and 2ω frequencies from surface, thin film and semiconductor heterojunction are derived. The essential role of quantum interference of transition paths (one-photon ionization at 2ω-frequency and two-photon ionization at ω-frequency) is demonstrated. This means that in photocurrent besides terms due to one- and two-photon ionization separately the interference term is of importance. This term is due to the fact that in the expression for the total probability of the process one has the squared sum of two amplitudes (one- and two-photon ionization) but not only the sum of their probabilities. Because the interference term depends upon the phase shift between monochromatic components $\varphi_1-2\varphi_2$ there is the possibility of the phase photocurrent control. In the present work the influence of the potential barrier shape on the photocurrent is investigated. The possibility of surface parameters determination with the aid of considered effect is analyzed. Such measurements are based on the compensation of the surface parameters alteration by means of the changing of phase difference $\varphi_1-2\varphi_2$.

Various manifestations of quantum interference in atoms and crystals are described in reviews [1,2]. The experiment on extrinsic photoeffect in bichromatic laser field had been made in the paper [3].

References.

1. Drabovich K.N., Krasnikov V.V., Manykin E.A., Pshenichnikov M.S., Solomatin V.S. Izv.AN USSR, ser. fiz. 1989, v.53, #4.
2. Dianov E.M., Starodubov D.S., Kvantovaya Elektronika, 1995, v.22, #5.
3. Baranova N.B., Zel'dovich B.Ya., Chudinov A.N., Shulginov A.A. Zh.Exp.Teor.Fiz. 1990, v.98, p.1857.

18:30-20:00 **PRESIDENT'S HALL**

ThX - Basic Concepts of Laser Chemistry, Biophysics and Biomedicine

ThX1

THE ORGANIC MOLECULES IN HIGH-POWER LASER FIELDS

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Lasing parameters of dyes are mainly determined by their radiative properties. Hence, study of luminescence in high power laser beams is interest. This seems to be especially important since there are publications where possibility of Einstein coefficients for spontaneous emission change and collective processes in high-power laser beams is discussed.

Fluorescence characteristics of ethanol solutions of rhodamine 6G, para-terphenyl derivated, coumarine 2, trans-stilbene and bifluorophore on the base trans-stilbene and coumarine 120, aqueous and ethanol solutions of 2-(4-pyridyl)-5phenyloxazole (4PyPO) and its dimethylaminoderivated on concentration 10^{-6} - 10^{-4} mol/l were studied. Fluorescence was induced by XeCl laser at λ=308 nm with τ_{FWHM}=10 ns, E_{out}=40-50 mJ. The form and dimension of excited volume have been variated. Radiation was observed in resonator and without resonator. The transparency, radiation pulse shape, spectra and phototransformation quantum yield were measured.

It is observed increasing of the transparency on exciting wavelengh for some dyes solution under high power excitation.There is no observed saturation of fluorescence intensity with excitation intensity up to 10^{26} phot/cm^2 s in coumarine, trans-stilbene, derivated of para-terphenyl and ethanol 4PyPO solution. Ethanol solutions of bifluorophore and aqueous solution of 4PyPO shown saturation of fluorescence intensity under excitation 10^{25} phot/ cm^{2}s, but there is no saturation for photocathion of 4PyPO formed in S_1 state and emitting at 470 nm. It is observed the variation of fluorescence pulse shape versus excitation intensity, excited volume and solution concentration. Spectra of this radiation and fluorescence spectra with weak excitation are equivalent except is a small shortwave shift and some widening of fluorescence band under high power excitation. Photostability of studied dyes under power excitation is better than with weak excitation.

ThX2

Vibrational distribution of ions H_2^+ under multiphoton ionization of hydrogen molecules

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We investigated four-photon (3+1) ionization

$$H_2(X^1\Sigma_g^+, v''=0) \xrightarrow{3\hbar\Omega} H_2(C^1\Pi_u, v') \xrightarrow{\hbar\omega_f} H_2^+(X^2\Sigma_g^+, v) + e^- \qquad (1)$$

with population of intermediate Rydberg $C^1\Pi_u$ state. Here v'', v' and v are corresponding vibrational quantum numbers, Ω is weak (probe) field frequency, ω_f is external laser radiation frequency. The theoretical investigation of process (1) having been carried out in the work [1] was not in a good agreement with experimental data on vibrational distribution of ionization products [2]. We analysed the process (1) using method of radiative collision **T**-matrix, where total wave function of the system with accounting for electromagnetic field in the final state is expressed via its elements [3]. The last is impossible in the method used in [1]. Formalism utilized allows to include naturally predissociation channel of intermediate complex $H_2^{**}(v')$ resonance states concerned with transition into repulsive $^1\Pi_g$ state. Without field ($f=0$) it causes the ultimate shift of distribution function W_0 to the greater v values with respect to Franck-Condon distribution. Interaction with field in final state forms the additional ionization channels and effects essentially on profile of ion distribution H_2^+ on final vibrational states that has nonmonotonic dependence on external field strength f. At low field strength $f \leq 10^{-5}$a.u. it provides the additional field broadening of resonance levels and shift of spectrum pattern toward the less v values comparing with W_0. This dependence becomes more complicated at higher field strength $f \geq 10^{-4}$a.u. that is connected with multiphoton character of absorption and appearing of new reaction channels.

The dependences of ion H_2^+ vibrational distribution on strength magnitude and external field frequency are calculated.

1. Hickman A.P., Phys.Rev.Lett. **59** 1553 (1987)
2. O'Halloran M.A. et al J.Chem. Phys. **87** 3288 (1987)
3. Ivanov G.K., Golubkov G.V. JETP **72** 783 (1991)

ThX3

DESORPTION OF PHYSISORBED MOLECULES THROUGH THEIR ELECTRONIC EXCITATION BY RADIATION OF EXCIMER LASERS

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The desorption of adsorbates is of importance for laser heterogeneous chemistry as it allows to control reaction pathways. We studied desorption initiated by molecular absorption of UV pulsed laser radiation. Several molecules with different number of atoms, namely NO, SO_2, NH_3 and C_6H_6, have been considered to elucidate a role of rovibrational structure in desorption mechanism. The molecules were adsorbed on a cooled UV grade quartz specimen. Wavelengths of radiation were chosen so that a molecule strongly absorbed it but not efficiently fragmented. UV desorption was compared with a thermal one induced by substrate heating by a TEA CO_2 laser.

Laser-induced desorption was investigated using a quadrupole mass spectrometer in time-of-flight mode. The dependences of desorption yield on laser fluence and adsorbate coverage have been measured and velocity distributions of desorbed species have been analyzed in terms of a modified Maxwell-Boltzmann distribution.

One-photon desorption of NO at 193 nm, nonlinear processes with power indices of 2 or 3 for SO_2, NH_3 at longer wavelengths and a threshold-like KrF laser desorption of C_6H_6 have been observed. The electronic relaxation of excited molecules results in an excitation of molecular vibrations and adsorption bonds. In C_6H_6, an efficient thermalization of electronic energy can occur so that this desorption resembles a thermal one. In small molecules, adsorption bonds may be broken before thermal equilibration. As neither fragments nor ions were detected, then 2 or 3 photons needed for SO_2 or NH_3 desorption to occur were likely absorbed successively rather than simultaneously.

Velocity distribution of desorbed species may be critically modified by intensive collisions near the surface. The molecules may acquire a certain stream velocity. Its value is highly sensitive to desorption mechanism and collisions. The behavior of this parameter as well as a translational temperature has been studied in details and will be discussed.

ThX4

SUPPRESSION OF SINGLET OXYGEN GENERATION BY HIGH-POWER LASER PULSE

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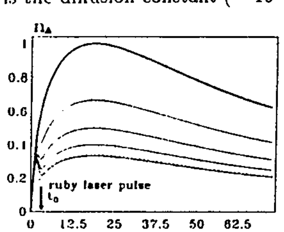
The active $^1\Delta_g$ form of O_2 can be prepared by excitation of ordinary $^3\Sigma_g^-$ triplet oxygen with light in the presence of a sensitizing dye. The important problem of photobiology is the determination and control of the $^1\Delta_g(O_2)$-density n_Δ in condensed mediums. In our experiments this population is visualized by delayed fluorescence (DF) of the organic component (sensitizer) [1] as the result of reaction $T +^1 \Delta_g(O_2) \to 0$ (T is the sensitizing triplet state of the dye). The system is excited by laser pulse (Nd^{3+}, 20 nsec, 532 nm, 10 mJ) and then, after time t_0 the additional intensive laser pulse (ruby, 694 nm, $E \sim$100mJ) is used. We investigate the time evolution of density $n_\Delta(t)$ and DF intensity $I_{DF}(t)$ for $t > t_0$. It was found [2]. that if the laser radiation frequency is within a band of the chromophore T-T-absorption fell, then the T-centers density n_T and the intensity I_{DF} sharply decay (60-80% effect). The $T -^1 \Delta_g(O_2)$ annihilation kinetics becomes radically different from the case without added pulse. For the second laser pulse intensity $\sim 10^7 \div 10^8$ W/cm^2 the population of the lowest triplet energy level is decreased irreversibly. The detail description of the reaction $T -^1 \Delta_g(O_2) \to 0$ is produced by the set of correlation functions $f_{T\Delta}(r,t)$, $f_{T\Sigma}(r,t)$ and $f_{TT}(r,t)$ (two-particle densities).

For the density $n_\Delta(t)$ and DF intensity $I_{DF}(t)$ we obtine $(\Omega = \Sigma, \Delta)$

$$n_\Delta(t) = n_{ox} \int_0^t K_\Sigma(\tau) n_T(\tau) \exp\left[\frac{(\tau - t)}{\tau_\Delta} - \int_\tau^t n_T(\tau')[K_\Sigma(\tau') + K_\Delta(\tau')]d\tau'\right] d\tau;$$

$$I_{DF}(t) \sim n_T(t) n_\Delta(t) \left(\frac{\partial f_{T\Delta}}{\partial r}\right)_{r_\Delta}, \quad K_\Omega(t) = 4\pi r_\Omega^2 D_\Omega \left(\frac{\partial f_{T\Omega}}{\partial r}\right)_{r_\Omega}.$$

Where $n_T(t)$ is the concentration of T-centers; r_Ω is the reaction radius $(2 \div 5\mathring{A})$; D_Ω is the diffusion constant ($\sim 10^{-8}$ cm^2/s).



The analysis of the luminescent kinetics in polymers indicates that the spatial correlations of reactants is very important, and $K_\Delta(t)$ essentially depends on the time. The computer simulation data demonstrate that the singlet oxygen generation essentially depends on the parameters t_0 and E. The sharp laser quenching of T-centers in arbitrary moment allows to control the singlet oxygen generation by the light.

[1]. *M.G.Kucherenko.* Chem.Phys., 1994, **179**, P. 279-286;
[2]. *M.G.Kucherenko, M.P.Melnik et al.* Optika i Spektr., 1995, **78**, P. 649-653.

ThX5

SIMULATION OF LIGHT-INDUCED GRATINGS FORMATION IN SOLID SOLUTION OF THE DYE IN POLYMER

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The actuality of triplet photochromic system investigation connects with the decision of practical tasks of information recording, development of diagnostic methods in molecular nonlinear media. The decision of kinetic problems of light-induced chemical processes in condensed phase holds a special place.

In the paper the model of photo-induced dye reduction in interference light field under laser radiation in band of the first singlet-singlet transition was developed. At such condition in the film volume of the dye solid solution in polymer matrix the light-induced grating (LIG) is formed. The base of the model is three-level energy scheme of dye molecule (S_0, S_1, T_1) and also it includes set of photophysical and photochemical processes of dye transformation into colorless form through the intermediary of triplet state. In paper the familiar scheme of dye transformation into the colorless form with oxygen absence, which based on proton transport [1] from polymer matrix (in our case) was used. The model allows to observe time modification of medium components proportion (fig.1) and to use this information for calculation of kinetic parameters of photoproduct quantity and diffraction efficiency of LIG, which looks as test of it quality (fig.2.).

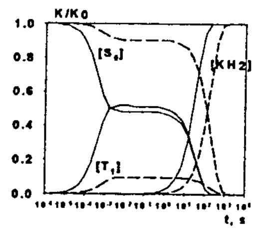

Fig.1 The concentration of initial form [S_0], triplet [T_1], colorless form [KH_2] of dye as function of irradiation time. The power of the light: 200mW (solid lines), 20mW (dotted lines)

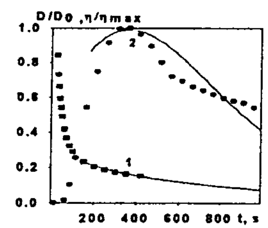

Fig .2 Time dependencies of film optical density D (1) and diffraction efficiency η (2). Symbols-experimental results, lines-simulation results.

The experimental results on LIG formation kinetic in solid solution of eosin K in gelatin [2] were analyzed on a model. The model has shown agreement with experimental data. Application of these data allows to find the value of rate constant of reaction of intermediate anion-radical dye form formation ($k=3\cdot10^{-3}$ s^{-1}). This stage in the set of reactions defines the grating recording rate. The influence of some peculiar to medium and radiation parameters was analyzed.

References.

1. *Terenin A.N.* Photonika molekul krasiteley. (L.: Nauka, 1967.)
2. A.A. Vorob'ev, S.A. Kolchanova, A.G. Sizykh and I.G. Sul'kis. Modelling, measurement and control, A, AMSE Press, 54, No.4, pp.27-36, 1994.

ThX6

STM/STS INVESTIGATION OF PHOTOHROMIC TRANSFORMATIONS IN NAPHTHACENEQUINONE MOLECULAR LANGMUIR-BLODGETT FILMS

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Schematic structures of two conformational forms (A and B) of 6-phenoxy-5,12-naphthacenequinone molecules which occur during photocoloration (A→B) and photobleaching (B→A) reactions presented in Fig.1.

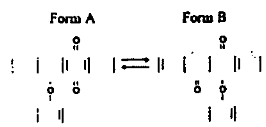

Fig.1

1. The distinct peak is found in tunnel local density of electronic states of 6-phenoxy-5,12-naphthacenequinone molecules ordered in LB films. Such a peak is inherent in both A and B forms and is indicative of two-dimensional (2D) character of film conductivity. The form of the differential conductivity curve is proved to be significantly modified after reverse photoisomerization (Fig.2).
2. For molecules in A form the additional subband in the range of empty electronic states of LB films has been detected;
3. The tunnel current flowing through the LB film falls from ~0.1 nA to ~0.04 nA when molecules transfer from A to B form;
4. Constant height images of individual molecule in form A demonstrate an additional fine structure that indicates to the conformational transition of molecules from A to B form. This transition is connected with transfer of the phenoxy group from one oxygen to another and probably leads to shutdown some tunneling channels.

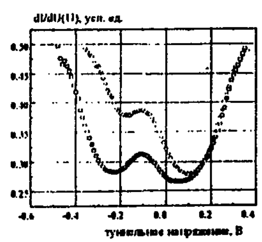

Fig.2

ThX7

CHEMICAL REACTIONS of CF_3CHClF INITIATED BY PULSED IR-RADIATION

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The dependencies of product yields were investigated in SF_6-sensibilized laser pyrolysis and IR multiphoton dissociation (MPD) of CF_3CHClF. Both methods of IR-initiation were shown to result in the same stable products: C_2F_4, n-C_3F_6, 2-C_4H_8, C_2ClF_3, and C_2HF_3. The results of work show that the primary freon decay occur through a multichannel path, which agree with known data [1]:

$$CF_3CHClF \xrightarrow{nh\nu} \begin{cases} CF_3CF: + HCl (1) \\ CF_2CClF + HF (2) \\ CF_3HF^{\bullet} + Cl^{\bullet} (3) \end{cases}$$

The probing of a reaction mixture with **KrF**-laser radiation at λ=248 nm has shown presence of $:CF_2$ which are formed due to partial secondary fragmentation of $:CFCF_3$. The formation of the main final product (C_2F_4) results from reactions (4) and (5)

$$2{:}CF_2 \rightarrow C_2F_4\ (4) \qquad :CFCF_3 \rightarrow C_2F_4\ (5)$$

The channel of formation n-C_3F_6 is to be recombination of $:CFCF_3$ and $:CF_2$ (6)

$$:CFCF_3 + :CF_2 \rightarrow n\text{-}C_3F_6\ (6)$$

A small amounts of 2-C_4H_8 can form due to recombination of $:CFCF_3$-radicals.

IR-laser photolysis of CF_3CHClF with $CHClF_2$ (as additional source of $:CF_2$ testify n-C_3F_6 formation to occur through reaction (6).

It was also shown that the real distribution of final products of laser-induced transformation of CF_3CHClF can be observed if only isomerization of $:CFCF_3$ (5) takes place.

The Arrhenius parameters of reactions (1) and (2) were calculated by the "chemical thermometer" method: E_{a1} = 59.2± 2.5 kcal/mol, A_1 = $(1.27\pm0.14)\cdot10^{12}$ s^{-1}, E_{a2} = 70.02±3.5 kcal/mol, $A_2 = 2.7710^{14}$ s^{-1}.

1. Kato S., Makide Y., Tominaga T., Takeushi K., Laser Chemistry, 1988, 8, 211

ThX8

6-PHENOXY-5,12-NAPHTHACENEQUINONE PHOTOISOMERIZATION UNDER EXCITATION BY FEMTOSECOND LASER PULSES AT WAVELENGTH 308 NM.

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The photochemical transformation of naphthacenequinone derivatives is of great interest due to the applicability of such compounds to erasable 3D optical data storage systems as well as to holographic memory application. The photoisomerization of 6-phenoxy-5,12-naphthacenequinone in toluene solution and in polymethyl methacrylate (PMMA) host has been investigated. The photochromic properties of naphthacenequinone derivatives are consisted with transformation of para (form A) to ana (form B) quinoid forms. The pump-probe method with 100 fs resolution has been used in our experiments. As a pump pulse we used the femtosecond laser pulse at wavelength 308 nm. As a probe pulse we use spectrally filtered supercontinuum with the following wavelengths: 460, 495 and 540 nm. It has been shown that the transition state with absorption maximum at 460 nm relaxed with the rate $(2\ ps)^{-1}$. Subpicosecond pump probe measurements of the photoisomerization of this compound embedded into PMMA host show no significant absorption of the triplet states in the range of 80-100 ps time delay, which were shown earlier for solution under illumination at 355 nm.

The experimental results enable us to propose that the photochemical reaction proceeds via singlet excited state with additional vibrational excitation. The quantum-chemical calculations of the PES has been performed for ground and excited states along two most probable reaction coordinates. The results of calculations show that without the vibrational excitation the photochemical reaction can proceed only via triplet states, while potential energy barrier on the singlet potential energy surface can be overcome by vibrational excitation.

ThX9

GOLD PARTICLES FORMATION BY NUCLEATION UNDER LASER RADIATION

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The mechanism of nucleation and formation of the condensed phase of neutral metals in solution are key tasks within the framework of new materials production. In the present work the conditions influencing on nucleate clusters of gold in solutions and the mechanism of growth of its nanoparticles under laser irradiation are investigated.

The experiments were carried out with solutions of $HAuCl4$. Excimer laser was used as a source of radiation. The size and the forms of produced nanoparticles were studied by electron microscope.

First of all the matrix of solution influences on nucleating, growth and formation of particles. The acidity of solution determine the size and form of generated particles. The average size of clusters generated in 0,5 M HCl is 1-2 microns. The particles represent as conglomerate of balls with a diameter 100-150 nm. In 2 M HCl the fine rise similar particles of gold with the average size 100-150 nm produce. The balls of gold (0) with the size ~ 100 nm are formed in solutions with 3 M HCl.

Intensity of laser radiation, duration of irradiation and density of radiation also influence on nucleating, form and development of gold clusters. With increasing of the intensity of laser beam the size of the generated particles is increased by sticking together of fine particles under a strong flow of laser radiation and, probably, by reorganization of the form originally produced microparticles..

Under the low radiation density the flat microparticles gold (0) size 50 nm x 50 nm of a various configuration such as flat triangles, trapezes, six angles up to pyramids are produced. With increasing of the radiation desity in 5 times these particles stick together and are reconstructed with formation of particles of the homogeneous spherical form by the size 300 nm x 300 nm.

ThX10 STEP-WISE STRUCTURAL REARRANGEMENT OF DICARBOCYANINES INDUCED BY PHOTOEXCITATION

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Dicarbocyanine dyes undergo structural rearrangement upon excitation related to the rotation of a stable molecule (SM) fragment around the central (the 3d) C-C bond in a chain. Therewith the instable photoisomer (PI-1) is formed

We studied step-wise photoisomerization of dicarbocyanines by methods of nanosecond pump-probe laser spectroscopy using one and two-frequency excitation techniques. Excited PI-1 undergoes photoisomerization via two channels, including recovery of SM and formation of instable photoisomer of another type, PI-2. The spectrum of PI-2 is shifted toward shorter-wave range with respect to that of SM. At one-frequency excitation the PI-2 concentration increased, as the excitation wavelength approached the maximum of the PI-1 absorption and also with increasing the pulse length. At two-frequency excitation, the first pulse served to form PI-1, whereas the second pulse, delayed in time, to excite solely the PI-1 molecules. The transient concentration of PI-1 jump-wise decreases upon excitation, while that of SM and PI-2 increases. For some molecular structures the probability of PI-1 formation and SM recovery are close, whereas for another structures, the mechanism of PI-2 formation is predominant. In the latter case we estimated, using two-frequency excitation, the activation energy of PI-2 formation. The activation energies for the first and the second photoisomerization steps differ by no more than 500 cm^{-1}. The ground state relaxation of PI-2 causes the ground state of SM to be recovered via two channels differing in the intermediate states. One of these intermediate states is the ground state of PI-1.

We conclude that PI-2 is di-cis-isomer formed upon step-wise rotations around the 3d and then around the 5th bond. Two channels of SM recovery suggest the same and the opposite sequnce for these two rotations. The photoisomerization activation energy by rotation around the 5th bond is lower in PI-1 than in SM, which is explained by assymetrical chain structure of PI-1 that increases alternation of the bond order.

ThX11 THE MECHANISM AND KINETICS OF PERFLUORINATED OLEFINS OXIDATION WITH MOLECULAR OXYGEN UNDER IR MULTIPHOTON EXCITATION.

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The transformations of olefins C_2F_4 and C_3F_6 in O_2 mixtures were studied under IR multiphoton excitation (MPE) by TEA CO_2 laser radiation in a multipulse mode: for C_3F_6 at frequency ω_L = 1027,5 cm^{-1} (parallel beam, fluence 0,24-0,34 J/cm^2), for C_2F_4 in a range of frequencies ω_L = 1029,4-1090,0 cm^{-1} (focused beam, focal fluence 21 J/cm^2). The pressure of olefins was 5 Torr; the pressure O_2 added ranged from 0,5 to 25 Torr. Stable products were analyzed by IR-spectrophotometry and gas chromatography.

Final products of C_3F_6 oxidation were CF_3CFO and CF_2O (CF_3CFO was always present in excess), and trace amounts of C_2F_4 and 2-C_4F_8. On the basis of analysis of final products of C_3F_6 oxidation it was concluded that dominant process of CF_3CFO and CF_2O formation is the bimolecular reaction C_3F_6 with O_2. It's likely that intermediate (dioxetane) is formed at a primary stage and subsequently can convert on various pathways and result in non-stoichiometric mixture of CF_3CFO and CF_2O. It was also revealed that in mixtures C_3F_6 with lack of oxygen CF_3CFO formed after early pulses effectively decomposes with formation CF_2O. These results permit to remove the contradictions in prospective mechanisms of oxidation C_3F_6 under IR MPE [1] and SF_6-sensibilized laser pyrolysis [2]. Because interaction C_3F_6 and O_2 occurs in reaction mixture heated after vibrational relaxation varying of O_2 pressure and thus postpulse temperature, allowed us to estimate effective activation energy of primary stage of interaction C_3F_6 and O_2: $E_a = 28,2\pm3,3$ kcal/mol.

The oxidation C_2F_4 with O_2 was carried out in the focused radiation mode and observed even if frequency of the laser radiation was shifted from the absorption maximum of C_2F_4 by 150 cm^{-1}. Under these conditions the only product of C_2F_4 and O_2 interaction was CF_2O that confirms dioxetane mechanism of the oxidation. The dependencies of C_2F_4 oxidation rate on O_2 pressure, frequency and energy of laser radiation were found.

1. W.S.Nip, M.Drouin, P.A.Hackett, C.Wi, J.Phys. Chem., 1980, 84, 932.
2. J.Pola, Z.Chvatal, J.Fluor. Chem., 1987, 37, 197.

ThX12

THEORETICAL STUDY OF VIBRATIONAL HEATING / COOLING OF NICKEL(II) OCTAETHYLPORPHYRIN IN SOLUTION

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Nickel(II) octaethylporphyrin (NiP) is considered as an exemplary system for studying primary photophysical processes in metalloporphyrins and related biological molecules. Photoexcitation of NiP in non-coordinating solvents is followed by the complex decay process in which 3 kinetic components can be separated ($\tau_1 < 350$ fs, $\tau_2 \sim 10$ ps, $\tau_3 \sim 300$ ps) [1]. The first and the third kinetics represent electronic relaxation processes $(\pi,\pi^*) \to (d,d)$ and $(d,d) \to S_0$, respectively [1], while the second one primarily represents the processes of non-electronic origin including vibrational heating/cooling and conformational dynamics [2]. Recent picosecond anti-Stokes resonance Raman study of NiP [2] observed various time delays in the hot Raman bands formation and revealed that the redistribution of electronic energy excess over the vibrational degrees of freedom is mode-selective and that the intramolecular vibrational energy redistribution is not complete in femtosecond time scale.

In the present study, we theoretically investigated the relaxation dynamics of NiP on the basis of 5-level model system focusing on the kinetic behavior of the modes ν_4 and ν_7 obtained in the experiment [2]. In order to account for the observed peculiarities of vibrational heating/cooling process, the mechanism of vibrational mode energy exchange between the considered mode (ν_4 or ν_7) and other vibrational modes of NiP and solvent bath has been included into consideration. The details of the model, the approximations used and the results obtained will be discussed in the report.

1. J. Rodriguez, D. Holten, J. Chem. Phys. 91 (1989) 3525.
2. S.G. Kruglik, Y. Mizutani, T. Kitagawa, Chem. Phys. Lett. 266 (1997) 283.

ThX13

THE EFFECT OF GIANT CLUSTERS PHOTODISSOCIATION AND PHOTOIONIZATION ON DYNAMICS OF CARBON LASER PLUME.

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Laser plume structure and parameters were for a long time at the scope of laser physics. But until recently there is not clear understanding of some facts concerning nature of laser plume "opaqueness" region and thermodynamic state of evaporated substance near target surface.

Intersection of spinodal curve at laser evaporation of polycrystalline graphite target at threshold power density value 0.3 GW/cm2 has been determined by optoacoustic procedure as point of transition from evaporation to hydrodynamic expansion of the material heated. The spinodal decay of the carbon labile state resulted in appearance of giant cluster ions (multiply charged in part) up to million atoms in size at time-of-flight mass spectra recorded. Giant carbon clusters are known to possess of macroscopic characteristics and for the reason photodissociation and photoionization of the species through multiphoton absorption proceed as evaporation phase transition and thermoelectronic emission correspondingly.

Laser-evaporated substance stays in labile state behind spinodal curve during initial step of laser plume gasodynamic expansion and interaction with laser radiation. Therefore bulk absorption and considerable density fluctuations in the substance seem to be responsible for optical "opaqueness" of the laser plume region. Local temperature in the region estimated by Saha equation for multiply charged cluster ion intensities didn't exceed 20 000 K as well as the estimated local plasma density had the subcritical value up to the moment of overall dissociation of the clusters. Further total ionization of carbon vapour took place in hot region of laser plume at local temperatures from 30 000 to 110 000 K depending on laser power density used.

ThX14

Dynamics of physisorption and photoisomerization of cis-stilbene molecule on a graphite substrate

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Present paper is focused on a detailed examination of excited state dynamics in stilbene molecule, both isolated in the gas phase and physisorbed on an inert surface. By obtaining a fundamental understanding of the processes this molecule can undergo in both environments, we hope to gain insight into not only how desired isomerization channels in the case π-systems might be enhanced and controlled, but also how a surface can influence a photoisomerization process.

The main steps of our investigations can be outlined as follows [1]. First, an empirical Born-Oppenheimer potential surface is constructed for the isolated molecular system of interest using a combination of spectroscopic fitting techniques, ab initio information about the molecular structure, and standard molecular modeling force fields. If necessary, surfaces for both the ground electronic state and one more excited electronic states are constructed. The interaction of the system with a radiation field is then simulated to determine the non-stationary state that is prepared by an ultrafast (i. e. femtosecond) laser pulse using a semiclassical algorithm developed by us [1]. Finally, the molecular dynamics of that non-stationary state is simulated using classical molecular dynamics (MD) algorithms. We have applied this thechnique to simulate the ultrafast single molecule's dynamics of photoexcited stilbene molecule on a surface, focusing just on cases involving only "physical interactions" in the molecule-surface system, with no chemisorption.

In our computer experiments we first investigated physisorption dynamics of cis-stilbene molecule on a graphite substrate, which potential was calculated as a contribution from several (up to 10) upper atomic layers consisted of "frozen" atoms (static contribution) of the substrate [2] and a separate contribution from the upper layer atoms of which can move in the total potential. As a result of MD simulation of physisorption dynamics we revealed 7 stable configurations of physisorbed cis-stilbene molecule on a graphite substare, two of which are essentially different. Taking these stable configurations as initial ones we then simulated, in the vein of the above described algorithm, photoisomerization dynamics of physisorbed cis-stilbene excited by ultrashort laser pulse. Our calculations show that isomerization dynamics of photoexcited surface-adsorbed *cis*-stilbene molecule is slower by contrast to the isolated molecule's dynamics [1]. Physisorption does not relax the ability to undergo *cis-trans* photoisomerization, but the distribution between the isomerization channels is considerably different.

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1. V. D. Vachev, J. H. Frederick, B. A. Grishanin, V. N. Zadkov, N. I. Koroteev, J. Phys. Chem., 99, 5247 (1995); B. A. Grishanin, V. N. Zadkov, V. D. Vachev, and J. H. Frederick, JETP **82**, 1088 (1996).
2. R. G.Winkler, R. Hentschke, J. Phys. Chem., **100**, 3930 (1994).

ThX15

PHOTOINDUCED BEHAVIOR OF WATER-SOLUBLE Co(II)- AND Co(III)-PORPHYRINS IN INTERACTION WITH POLYNUCLEOTIDES, STUDIED BY RESONANCE RAMAN SPECTROSCOPY

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In this work we present the results of resonance Raman (RR) study of water-soluble cationic porphyrins Co(II)- and Co(III)(TMpy-P4) (Co(II)P and Co(III)P, respectively) in interaction with calf thymus DNA and DNA-model polynucleotides poly(dG-dC)$_2$ and poly(dA-dT)$_2$. At high-power pulsed excitation RR spectra of Co(II)P in DNA and poly(dA-dT)$_2$ exhibit new transient bands at 1356 and 1554 cm^{-1}. These bands grow in intensity with the increase of excitation power and the picture of photoinduced transformations are fully reversible. The extra bands are not observed for free Co(II)P in solution and for Co(II)P mixed with poly(dG-dC)$_2$. When RR spectra are measured with cw excitation, these additional bands do not appear either.

RR spectra of Co(III)P in interaction with all studied polynucleotides were recorded in the same experimental conditions. All the spectra do not exhibit the additional bands at neither cw nor pulsed excitation. They are quite similar to the spectra of Co(III)P alone in solution, where porphyrin is known to be axially ligated by two water molecules.

Possible nature of new extra bands in RR spectra of Co(II)(TMpy-P4) mixed with DNA and poly(dA-dT)$_2$ and absence of photoinduced transformations in the same spectra for Co(III)(TMpy-P4) are discussed on the basis of results obtained and analysis of literature data.

ThX16

Experimental investigation of laser-induced thermochemical and hydrodynamical processes by means of laser monitor with computer processing of images.

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SUMMARY

Thermochemical and hydrodynamical processes induced the laser radiation on surface of materials are considered. We developed experimental method of visualization by means of laser brightness amplifier and computer processing of images for interaction of laser radiation with material which allowed to observe the chemical transformations on the surface of metals and hydrodynamical processes in the melting container in a real time scale. The region of thermochemical transformations (i.e. oxidation) is identified as spreaded out from the center of the laser spot a dark front on a light background on the surface of metal. Computer processing allowed to determine reflection ability of surface under laser action. The oxide layer thickness was calculated on reflection ability by means theoretical model. The distribution of oxide layer on surface in the field of laser action was obtained. The hydrodynamical processes is identified by us as changes of reflection of copper laser radiation from the material surface. Particle of a material with high reflective ability were used as markers for the best visualization of process. The motion of melted material flows was fixed on movement of markers. Computer processing of images allowed to obtain trajectories of melted material flows.

ThX17

NONLINEAR POLARIZATION ROTATION OF LASER RADIATION IN BIOLOGICAL MOLECULES

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It is well known that solutions of natural amino acids (except glycine) have natural optical activity and rotate a plane of polarization of passing laser beam. This solutions in strong laser field have also nonlinear optical activity . (NPR) effect in

In this paper we report the first observation of nonlinear polarization rotation (NPR) effect in solutions of glycine (amino acid), which has not natural optical activity.

In our experiments a linearly (or elliptically) polarized laser beam (peak power 500 kW, linewidth 0.2 cm^{-1} , pulse duration 20 ns) was passed throught a quartz cell, 20 cm long, which served to contain a glycine solution (H_2O, 0.1 Mole, 25°C).

We are experimentally investigated the following dependencies of the NPR angle (φ) in the solutions of glycine.

1.Dispersional dependency - $\varphi(\lambda)$, λ=300-700 nm. Measured angle of NPR is equal to zero under the linear polarization of laser beam at all wavelength. Detuning of the laser radiation wavelength to the LE-absorption band of the chromophore group (COOH-group,π-π transition on 280nm) leads to resonant increasing of the rotation angle.

2. NPR angle of laser radiation versus laser beam intensity - $\varphi(I)$. The efficiency of NPR effect depends on intensity of laser radiation and its ellipticity.

3. Variation of the rotation angle as a function of laser beam ellipticity - $\varphi(\theta)$. The NPR angle strongly depends on the ellipticity of incident laser beam.

4.Variation of the rotation angle as a function of the solution protonism degree - φ(pH) at λ = 530 nm. The magnitude of NPR angle increases under the transfer from alkaline to neutral and from neutral to acidic form of molecules of the glycine.

Behaviour of experimental curves $\varphi(I)$ and $\varphi(\theta)$ shows the nonlinear nature and elliptical origin of the observed rotation effect. On the basis of the experimental results and theoretical calculations we proposed following mechanism of NPR effect - laser induced resonant nonlinear gyrotropy in the initial nongyrotropic medium. Cubic nonlinear susceptibility of the glycine are calculated for obtained experimental data.

ThX18

Collisional relaxation of vibrationally excited complex molecules following laser excitation: effect of supercollisions

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Up to now only a restricted member of physical methods for observing collisional energy transfer (*CET*) from vibrationally excited polyatomic molecules are known, although the nature of *CET* in such a case has not been clearly understood. In present work characteristics of time-resolved delayed luminescence (*DL*) induced by N_2- or CO_2 laser excitation of triplet molecules were used to determine the efficiency of vibrational energy transfer and average energy transferred per collision for mixtures of vibrationally excited polyatomic (*benzophenone* or *acetophenone*) with bath gases: *He, Ar, Xe*, C_2H_4, SF_6, C_5H_{12}. The decay rates of *DL* were analyzed at different time resolution of detection systems to study the influence of the nature of vibrational relaxation: vibration–vibration (*V–V*) or vibration–translation (*V–T*) transfers on *CET* quantities.

It was shown that time resolution about 10^{8} *sec* permit one to divide the *V–V* and *V–T* transfer for such large and complex molecules as *benzophenone* and *acetophenone* which were excited in quasicontinuum of vibrational states. In such a case the relaxation occurs in two stages. Upper level relaxed through *V–V* transfer, which completes after several collisions. At relatively small internal energy E_{vi}<10000 cm^{-1} the substantial amount of $\langle \Delta E \rangle$ typical for supercollisions, is transferred into *CET* of vibrationally excited polyatomic with polyatomic bath gases. Based on *V–T* data, it was concluded that the majority of energy transfer collisions involve *V–T/R* transfer of relatively small energies. For instance, at E_{vi}=9470 cm^{-1} of *benzophenone*, the $\langle \Delta E \rangle$ values in pure vapor are decreased from 2075 cm^{-1} for *V–V* transfer to 4.4 cm^{-1} for *V–T* transfer.

Comparison of these data with ones obtained at CO_2 laser multiphoton excitation of triplet molecules has confirmed this interpretation. Essentially, the CO_2 laser excitation method to measure the *DL* quantities has the lower time resolution: vibrational equilibrium establishes during the laser pulse and thus it is possible to obtain only the *V–T CET* quantities. The $\langle \Delta E \rangle$ values for *V–T CET* obtained by both methods are found to be close.

It was shown that classical simulation of the requisite quantities is not valid for molecules under study at accessible energy: *1)* classical and quantum distribution of the average energy residing in the vibrational mode are different; *2)* high frequency modes are "energy poor", while the low frequency modes are "energy rich". The statistical model based on the ergodic assumption was employed to describe the fast *V–V CET* process. It was shown, that satisfactory correlation between the energy transfer quantities and the predictions by simply ergodic collisions theory were found in the case of *V–V* energy transfer.

ThX19

SUB-PICOSECOND LASER CONTROL OF VIBRATIONALLY STATE-SELECTIVE PHOTOASSOCIATION AND ACCELERATION OF NEUTRAL ATOMS: MODEL SIMULATIONS FOR THE COLLISION PAIR O+H

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This work presents the extension of our first study of the photon-induced dynamics of a collision pair (O+H) interacting with an infrared picosecond laser pulse [1,2]. There is a competition between non-reactive processes such as elastic and inelastic scattering of collision partners and reactive processes induced by infrared picosecond laser pulses. In the case of inelastic scattering, absorption of one (or more) photons leads to acceleration of the collision partners. In our consideration, accelerations of up to 1.6 eV can be achieved by absorption of four photons. For this case it is shown that with increasing laser intensity, the probability of elastic scattering is lowered while the probability for higher-order processes increases corresponding to higher acceleration of collision partners. This process exhibits certain analogies with the phenomenon of above threshold dissociation (ATD) in which the peaks of the kinetic energy distribution of the photofragmets are separated by the photon energy [3]. In the case of reactive scattering, induced emission of one (ore more) photon results in stabilization of the complex leading to photoassociation. This process exhibits many analogies with the reversed process of state-selective photodissociation [3]. With the optimal choice of the laser pulse and the timing of the process, we show that the fraction ~ 85% of the scattering wave packet can be bound into specified vibrational state with a very high selectivity (99.99%).

1. M.V. Korolkov, J. Manz, G.K. Paramonov, B. Schmidt, Chem. Phys. Lett. 260 (1996) 604-610.

2. M.V. Korolkov, B. Schmidt, Chem. Phys. Lett. 272 (1997) 96-102.

3. M.V. Korolkov, G.K. Paramonov, B. Schmidt, J. Chem. Phys. 105 (1996) 1862.

ThX20

TWO-PHOTON DESTRUCTION OF PHOTOCHROMIC FULGIDES

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Photochromic fulgides are potentially promising canditates to be materials in the erasable high-density optical memory. Inspite of known high photostability of this substance under single-photon excitation we observed the significant destruction of this substance using two-photon excitation. Single-photon isomerization of this compound can be induced by illumination at 400 nm, while the reverse photoreaction can be induced by illumination at 500 nm. Two-photon excitation of the direct photoreaction has been performed using the femtosecond Ti:sapphire laser.

Photochemical reaction kinetic of indolyl fulgides embedded into polymer matrix were studied under two-photon excitation. The two-photon absorption cross-section was measured and proved to be $\delta = 1.7\text{-}2.0\cdot10^{-50}$ $cm^{4}\cdot s$.

To clarify mechanism of observed destruction we performed theoretical calculation of exited state energy and potential energy surfaces (PES) for investigated substances using the semi-empirical quantum mechanical method. We also assume that the triplet states take part in the photochemical reaction under two-photon excitation. We suppose that the photo-isomerization in this case proceed not only via the lowest excited singlet state S_1, but also via the direct excitation of triplet state T_1 which leads to significant photodestruction.

ThX21

PHOTOPROCESSES IN SUBSTITUTED p-TERPHENYL IN SOLUTIONS AND MPMMA MATRICES

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There are not so many high efficient liquid lasing media and no solid state lasing media exist for blue spectral region. We offer a new lasing medium, namely 1,8-$CO_2C_4H_9$ substituted p-terphenyl (LAC-1) with high performance both in solutions and in modified PMMA (MPMMA). The lasing efficiency of LAC-1 gains the value equal 40% in ethanol solution and 19% in MPMMA. The efficiency for LAC-1 obtained in our experiments twice exceeds the corresponding value for p-terphenyl. LAC-1 as well as p-terphenyl has high photostability. The lasing parameters were studied with $XeCl$-laser pumping ($\lambda_p = 308$ nm, $\tau_p = 10-40$nc, $E_p = 40-150$ mJ) in transversal configuration.

Dependence of lasing efficiency and pulse duration versus pumping intensity and pulse duration was examined.

To explain the difference in lasing properties between LAC-1 and p-terphenyl we have investigated the spectral luminescence properties and T-T absorption spectra both experimentally and by methods of quantum chemistry.

The electron structure of the above substances and rate constants of different photophysical processes that take place in them have been calculated.

As it was shown in our investigations the high efficiency of LAC-1 may be breafly explained as follows. LAC-1 has higher fluorescence yield, higher molar extinction coefficient at $\lambda_p = 308$ nm, lower T-T absorption intensity with respect to p-terphenyl and its T-T absorption spectrum lies in more red region.

ThX22

THE ELECTRONIC STATE CHANGE OF ZIRCONIUM ATOMS BY PHOTOCHEMICAL TRANSFORMATIONS AT THE SURFACE OF ZIRCON ($ZrSiO_4$) INITIATED BY INFRARED LASER RADIATION

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The action of continuous CO_2 laser radiation (10^5 - 10^6 W/cm^2) on the crystal zircon has been investigated. It has been found that the laser irradiation of the surface of zircon results in a selective sublimation of silicon oxides as well as in a change of electronic state of a zirconium atoms included in the silicate matrix.

The change of electronic state of zirconium atoms is confirmed by the change of the relation of K and L components intensity in X-ray emission spectra recorded by a X-ray microprobe analysis of irradiated samples. This change is connected with the decrease of a shielding of inside electrons and the delocalisation of electron density into position of a defects. The appearance of nonequilibrium electronic states of zirconium atoms is accompanied with the creation of the defect metallic clusters, in which the part of oxygen atoms is removed by laser sublimation of silicon - oxygen groups.

ThX23

TRANSIENT HOLE BURNING VERSUS EXCITED STATE ISOMERIZATION IN CYANINE DYES.

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Femtosecond transient hole burning and hole broadening dynamics in competition with vibration relaxation and excited state (ES) photoisomerization were studied in two polymethine dyes, 1,1'-diethyl-2,2'-dicarbocyanine (DDI) and 1,1'-diethyl-2,2'-cyanine (1122-C) dissolved in n-alcohols and acetonitrile. Evolution of differential absorption spectra and kinetics at specific wavelengths were measured by means of conventional femtosecond pump-probe spectrometer with independently tuneable pump and probe light pulses both of sub-100 fs duration.

Transient hole burning and its equilibration in a few hundreds fs dominate fast dynamics in DDI. Transient hole filling is observed around the excitation wavelength as a fast decay of the ground state bleach. Corresponding delays in the blue- and red-shifted bleach and in the ES absorption were also observed. Slower thermo-activated photoisomerization depends on solvent shear viscosity as $\eta^{2/3}$.

In 1122-C we have observed typical for a barrierless photoisomerization evolution of the stimulated emission with ~100 fs decay close to the pump wavelength and progressively slower decaying red-shifted stimulated emission with an increasing rising component. This time behaviour reflects a downhill motion of ES population towards a twisted minimum of the ES, where an internal conversion takes place. Another observed prominent feature is a time lag (onset) in the ground state recovery (GSR) signal.

Internal conversion to the ground state results in formation of the initial stable molecular conformation and photoisomer, both vibrationally hot. Vibrational cooling is seen as a difference in the excited state population decay (~5 ps in EtOH) and GSR (~6 ps) in the stable conformation, and as pronounced blue shift of the photoisomer absorption band towards its equilibrium position at 545 nm.

Transient hole burning in 1122-C is less prominent possibly because of the fast dynamics of excited state population during isomerization.

ThX24

Multiphotonic processes and the physical bases of stochastic tomography

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This work is devoted to the description of physical bases of new method of reconstructive problem, the problem of the diagnostics of nonlinear media. It is supposed that every point of media is a source of consistent stochastic events - the generations of correlative quants wide-spreading with the curtain speed. For the description of this argodic system, it is used the theory of probability, in particular, the theory of streams which describes both the process of summary stream forming for the totality of the whole active space and the process of the physical measuring of streams with the intention of establishment of the distribution laws.

We have obtained the analytical expressions for density and function of distributions for summary stream which give the possibility to evaluate the basic characteristics of the whole stream. It is being discussed the problems of different determined and probable ways of the initial stream synthesis It have been formed the total problem of reconstruction with the use of stochastic theory of streams. We discuss the decision of this problem for correlative stochastic quantum streams and formulate the necessary and sufficient conditions of existence of the problem decision. Due to the application of real integer transform and the definition of characteristic function with the use of that transform ,namely, Hartly transform, it have been obtained the basic expression for the parameter of the stream for any point of emissive space. The analysis of the total expression of synthesing stream probability by the method of correlative quants allows to establish the optimal conditions of the preliminary preparation and the conduction of physical experiment in the field of stochastic tomography of the media with the intention of 3D properties study, the properties which are inhomogeneous in space and changeable in time.

ThX25

NONLINEAR OPTICAL EFFECTS OF THE TRANSIENT CHIRALITY:

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Recent achievements in the time-resolved laser spectroscopy have made possible considerable progress in the study of the intermolecular dynamics and, in particular, have renewed attention to the trans-cis isomerization of stilbene [1]. However, the conventional four-wave mixing spectroscopy, which is based upon the electric dipole cubic nonlinearity, does not depend on the presence of the inversion centre in the molecular structure. Correspondingly, the four-wave mixing spectroscopy is insensitive to the transient chirality which emerges when the fragment of an achiral molecule leaves the molecular plane to establish the new molecular architecture. Despite the fact that the transient chirality is the most distinctive feature of the isomerization process, it remains unexplored until now in molecular studies. We report on the theory of the nonlinear optical effects due to transient chirality and examine the methods chirality-sensitive polarization spectroscopy of a kinetic intermediate in the isomerization of stilbene and its derivatives.

Since the trans-cis isomerization of stilbene involves the rotation of the phenyl ring around the double ethylene bond, the molecule should possess optical rotatory power during the lifetime τ of the twisted intermediate. The emerging difference in the absorption coefficients $\kappa_{\pm}$ for right and left circularly polarized waves is found to be $(\kappa_+ - \kappa_-)/(\kappa_+ + \kappa_-) \propto (a/\lambda)\times(\Gamma\tau)/(1+\Gamma^2\tau^2)$ where a is the molecular size, λ is the wavelength, Γ is the electronic linewidth. We developed the theory of time-resolved spectroscopy of the chiral intermediates which based upon such chirality-sensitive nonlinear optical effects as the second harmonics generation and nonlinear optical activity.

1. V.D.Vachev, J.H.Frederick, B.A.Grishanin, V.N.Zadkov, N.I.Koroteev. Journ. Phys. Chem. **99**, 5247 (1995); J.L.Baskin, L.Banares, S.Pedersen, A.H.Zewail. Journ. Phys. Chem. **100**, 11920 (1996); T.Nakabayashi, H.Okamoto, M.Tasumi. Journ.Phys.Chem. A **101**, 7190 (1997).

ThX26

NONSTATISTICAL BEHAVIOR FOR IR MULTIPHOTON DISSOCIATION OF MOLECULES $C_3H_5Ge(CH_3)_3$.

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According to works [1,2] , the heavy metal atom is a blocker to intramolecular energy flow. This may lead to the energy localization in one initially excited part of a molecule by a heavy atom under IR multiphoton excitation (IR MPE) and nonstatistical behavior for next IR multiphoton dissociation (IR MPD). To check this supposition IR MPD of molecules $C_3H_5X(CH_3)_3$ (X - the light nonblocking atom C or the heavy atom Ge) :
$C_3H_5X(CH_3)_3 \dashrightarrow C_3H_5 + X(CH_3)_3$ was studied.

TEA CO_2 laser ($t_{1/2}$ = 100 ns), tuned to 10R(36) at 985 cm^{-1} , resonant to CH_2=CH bending vibrations was used. The energy of pulse - 0,04-0,36 J, pressure of vapour - 1-100 Pa. The energies were determined by opto-acoustic method.

It is found that the average internal energies absorbed by molecules $C_3H_5X(CH_3)_3$ on the dissociation threshold depend on X. They are equal to ~ 3,3D for X=C and ~ 1,6D for X=Ge (D- the dissociation energy of the bond C_3H_5-X). The measured values agree with those ones calculated on RRKM (Rice-Ramsperger-Kassel-Markus) theory for statistical energy distribution over the entire molecule or only over its part C_3H_5X , accordingly.

It is shown that the possibility of spontaneous fragmentation of radicals $X(CH_3)_3$ depends on X also. The spontaneous fragmentation occurs only for the light atom C. In accordance with the RRKM theory IR MPD of $C_3H_5X(CH_3)_3$ is followed by spontaneous fragmentation of radicals $X(CH_3)_3$ only under the statistical energy distribution over the entire molecule. The behavior of $C_3H_5Ge(CH_3)_3$ corresponds to nonstatistical intramolecular dynamics.

References

1. T.Uzer, J.T.Hyhes. Chem.Phys. 1989. V.139. №1. P.163
2. P.J.Rogers, J.J.Selko, F.S.Rowland. Chem.Phys.Lett. 1983. V.97. №3. P.313

ThX27

Comparative spectrochronography of different types of luciferases

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Firefly luciferase catalyses oxidation of luciferin in the presence of ATP and magnesium bicathions. The product of reaction is oxyluciferin in singlet electronic exited state and its deactivation is accompanied by the yellow-green bioluminescence λ_{max} = 560-570 nm [1]. Earlier a comprehensive study of reaction substrate, product and their complexes with the enzyme has been carried out by means of stationary fluorescence spectroscopy [2].

We investigated the influence of microenvironment on the spectral and kinetic properties of luciferin. Fluorescence decay curves and stationary spectra were measured in 7 different solvents and in complex with luciferase. The structure of luciferin (phenole or phenolat forms) was modeled by means of TEA. The closest coincidence of decay curves in the solvents with the decay curve in the complex with luciferase was obtained in water. It means that microenvironment of luciferase is not hydrophobic, as it had been determined earlier [3]. We revealed also the linear dependence of the position of maximum of fluorescence spectrum upon orientational polarizability of the solvent. Basing on this dependence we estimated the change of the dipole moment of luciferin upon the transition to the excited state to be 9D.

We investigated the dynamic properties of two firefly luciferases: Luciola Mingrelica, that contains the only tryptophan residue and Photinus Pyralis, that contains two tryptophan residues [4]. To get information about dynamic properties of protein matrix we used the method of fluorescence spectrochronography. As a result we have observed an increase of average lifetime at the longwavelength part of spectrum for both luciferases. Such increase is quite natural for the relaxation processes. As for Luciola Mingrelica, we can be sure that the red shift of time-resolved spectra is due to relaxation process of protein matrix around changed dipole momentum of the single tryptophan. However, the same can be not valid for Photinus Pyralis because of two tryptophan residues in this molecule. In our investigation we assumed that the environment of both tryptophans is the same, so they are indistinguishable. This assumption is based on the data of X-ray structural analysis [5] and stationary fluorescence data.

To estimate the relaxation time we have used the model of continuous relaxation of solvent, according to which the maximum of fluorescence spectrum shifts to lower energies according to exponential law [6]: $\nu = \nu_\infty + (\nu_0 - \nu_\infty)\cdot exp(-t/\tau)$. As ν_∞ we used the maximum of fluorescence spectrum in water which is known to be the most longwavelength. The estimated relaxation time in this case is approximately the same for both luciferase and is equal to 14 ns. We discuss the influence of ν_∞ on the observed relaxation time.

We also used the method of fluorescence spectrochronography to determine the influence of ATP on dynamic properties of luciferase.

References

1. McElroy W.D. and DeLuca M., // Chemiluminescence and Bioluminescence, New York, 1974, pp. 285-311.
2. Gandelman O.A., Brovko L.Yu., Ugarova N.N. and Shchegolev A.A., // Biochemistry (a translation of Biokhimija), 1990, v.55, № 6, pp. 785-789.
3. Gates B.J. and DeLuca M., // Arch. Biochem. Biophis., 1975, v.169, pp. 616-621
4. Conti E., Franks N.P., Brick P, // Structure, 1996, v.4, № 3, pp. 287-299.
5. Baldwin T.O., // Structure, 1996, v.4, № 3, pp. 223-229.
6. Lackovicz J.R., Principles of fluorescence spectroscopy, Plenum press, New York, 1983.

18:30-20:00 **PRESIDENT'S HALL**

ThY - Biomedical Optics

ThY1

Diffusing-wave spectroscopy of flows

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The technique of diffusing-wave spectroscopy (DWS) consists in deriving properties of random multiple-scattering media from measurements of the temporal autocorrelation function of scattered intensity. Both the characteristics of light-scattering particles (size, absorption and scattering coefficients, etc.) and the macroscopic dynamic structure of the sample may be studied by means of DWS. The technique has a considerable potential for application in medical diagnostics (imaging of tumors, non-invasive blood flow monitoring, diagnostics of burns, etc.).

We report theoretical and experimental results that allow the method of DWS to be extended to random media with hidden, spatially localized flows of scatterers. Our model experiments were performed with a flow of an aqueous suspension of polystyrene beads confined within a rigid sample made of titanium dioxide particles suspended in resin. Due to the multiple character of light scattering, the sample is opaque and the flow cannot be observed by eye. At the same time, when the sample is illuminated by a laser, the temporal autocorrelation function of diffusely reflected light turns out to be sensitive to the velocity of the hidden flow. Thus the method of DWS allows a non-invasive diagnostics of the flow.

As a possible application of the method, we discuss the use of DWS for non-invasive *in vivo* optical monitoring of blood flows in humans and animals. Preliminary analysis shows that the proposed technique is quite competitive with other methods of the same purpose.

ThY2

MATHEMATICAL MODEL OF UVA-INDUCED MELANIN SCREEN

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"Melanin screen" effect, i.e. the increase of epidermal absorption due to UVA-induced melanogenesis [1] leads to decrease of effective doses of UVA-radiation at subsequent photochemotherapy sessions. In the work the mathematical model of UVA-induced melanogenesis is developed. Processes on cellular, subcellular and molecular levels are described [2]. The model presents the system of the ordinary and partial differential equations for the number (density) of melanocytes in different states (Mc_j), mean number of melanosomes on different stages of maturity (age) in melanocyte (Ms_{mj}) or keratinocyte (Ms_k) and mean degree of melanization of melanosome at definite age τ ($Dm(\tau)$). Equations structure allows to split the problem and to consider a linear differential equations system at given intensity, to calculate a melanin content distribution and absorption coefficient [1], to define a new value of intensity etc. The melanin content in basal and suprabasal (ML_b) and upper (ML_u) layers is defined as

$$ML_b(t) = \int_0^\infty \left(\sum_j Mc_j(t) \cdot Ms_{mj}(t,\tau) + Kc(t) \cdot Ms_k(t,\tau) \right) \cdot Dm(t,\tau) d\tau,$$

$$ML_u(t) = \int_0^t \exp(\chi \cdot (t' - t)) \cdot ML_b(t') dt' + ML_u(0) \cdot \exp(-\chi \cdot t)),$$

where $Kc(t)$ - number (density) of keratinocytes that considered as predefined function; χ - rate constant for melanin exit due to desquamation of stratum corneum.

The time and dose dependencies of epidermal absorption coefficient are determined. Numerical results are in qualitative consistence with experimental data [1].

1. A.H. Mavlyutov, Yu.P. Sinichkin, S.R. Utz, Proc. SPIE 3053, pp. 183-195 (1997).
2. K. Jimbow, T. B. Fitzpatrick, M. M. Wick, in Physiology, biochemistry and molecular biology of the skin, Oxford Unit. Press, N.Y., 1991, pp. 873-909.

ThY3

Comparison of bioelectric responses of plants to local light irradiation in the visible and infrared ranges

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In our previous works it was demonstrated that the qualitative and quantitative estimation of the reaction of plants to the low-intense local laser irradiation can be performed by measuring bioelectric potential (BEP) gradients generated by the plants. BEP is the difference of electric potentials at the surface of a plant resulting from the difference of the functional activity of cells in tissues and organs. The analysis of the response of plants to the variation of the wavelength of the light, i.e., of the action spectrum (AS) of light on the plant, is an important method of the study of the photobiological processes. We determined the dependence of the bioelectric reaction (BER) of a plant on the wavelength λ of the coherent or incoherent irradiation. In the visible spectral range the dependence of BER on λ coincides with chlorophyll absorption spectrum. Reaction of the plant to the light irradiation in the infrared range (1015-3900 nm) is related probably to water absorption. The dependence of BER on intensity (I) is of the threshold type. We measured the dependences of BEP on I, on radius of the light spot (r) with several wavelengths. The wavelength dependence of the transmittance of an intact green leaf nearly coincides with its photoacoustic spectrum. Thus, the proposed nondisturbing method make it possible to determine the optical parameters of a living plant and to compare them with BERs.

The work has been supported by the State Program "Scientific Schools of Russia" (Grant N 96-15-97782).

ThY4

The changes of immune status of the sick with rheumatic arthritis under influence of laser therapy.

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The goal of the present research is to study the immune status of sick with rheumatic arthritis under influence of laser therapy. Under the supervision there were 28 patients with rheumatic arthritis, the indexes of immune status of whom were fixed before and after treatment. 32 patients with rheumatic arthritis who were under usual treatment were regarded as a control group.

The research of immune status included the following parameters formula of blood; the , quantity SD3, SD4, SD8, SD19 of lymphocytes (the research was conducted on a laser cytometer FACSCalibur, firm BESTON-DICKINSON, phagocytic activity of neutrophiles by the method of chemiluminescence. During the work various HeNe-lasers with wavelength 633 nm were used. For the intravenous irradiation of blood the dose for the one time from $1.69*10^{-1}$J up to $2.44*10^{-1}$J, the power from $3.33*10^{-4}$ W up to $5.74*10^{-4}$ W the duration for the one time from 60 up to 80 min, the full dose - $9.75*10^{-1}$J, number of times - 10.

The analysis of immune status of the sick with rheumatic arthritis in both groups before the treatment showed the reduction of SD3, SD8 lymphocytes, concentration of IgA and increase of circulating immune complexes (CIC). Changes of concentration of SD4, SD8 lymphocytes, lead to the increase of IRI. Functional condition of phagocytic activity of neutrophiles in blood had tendency to reduce.

The analysis of efficiency of medical influence showed that the sick under usual therapy hadn't any changes in the parameters of immune system, besides CIC, which had a tendency to reduce. The application of intravenous laser therapy within the process of complex treatment of examined patients lead to changes of both cellular and humoral links in the system of immune. There were observed the increase of SD3, SD8 of cells ($P<0.01$; $P<0.001$) and of IgA level and the reduction of CIC concentration. The concentration of IgM increased, as well, which proved the activation of the initial immune response. The level of SD19 of cell changed slightly. So, the intravenous laser therapy is followed by a positive changes in the immune system of sick with rheumatic arthritis and with improvement of clinical duration of disease

ThY5

ACOUSTIC CONTROL OF LASER CARTILAGE RESHAPING

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In this work, the preliminary results in the vibrometric study of the acoustic and opto-acoustic response caused by laser-induced stress-relaxation in cartilage are presented. Measurements of free- and forced vibrations of the cantilevered cartilage allowed us to detect the biomaterial elasticity alteration induced by laser heating up to 70-75 °C . As it have been found [1], the phase transition of the bound interstitial water in biotissue to its free state takes place in this temperature interval. It have been established, that the decrement of dumping of acoustic signal correlated with the decrement of free vibrations of the cantilevered cartilage. We have registrated the acoustic signal during laser treatment of the non-vibrated cartilage, when its temperature have risen once and cartilage reshaping process has been started. This response increase in amplitude and looks like a flicker noise.

Fourer analysis of this acoustic signal showed that the spectrum has a high power spectral density in low frequency and shown distinguished component with the character frequency. The same frequency component was in the spectra of acoustic signal of dumping free vibrations. We assumed that the observed acoustic signal corresponds to the sound which generates by the movement of liberating water. Acoustic signal of the liberated water may be chosen as a control parameter for the laser-assisted cartilage reshaping. This acoustic response detection could be used to design a laser control system for reshaping cartilage.

1. E.N.Sobol , V.N.Bagratashvili, A.P.Sviridov, A.I. Omel'chenko, et al. Proc. SPIE, 2128, 43 (1994).

ThY6

LASER–PLASMA TECHNOLOGIES FOR THE BIOMEDICAL PURPOSES: EXPERIMENT IN STOMATOLOGY

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Offered earlier [1] and good investigated [2] laser with short-term resonance modulation of losses (STRML) is a convenient and compact instrument for laser-plasma technological applications including medical. As perspective it is possible its applications for the laser-pulse punching of hollow organs, the laser-pulse lithotripsy etc. Now we have pursued research of such technology for stomatology. The radically new laser-plasma method for processing of the solid dental tissues realized by action on a treated material of the high-temperature laser plasma under an operation of the STRML-glass laser (ultrashort pulse duration ~50÷200 ps, energy ~1 J) has been designed. Advantages of this method are the dot character of plasma source, the essentially dominant channel of transformation of the laser radiation in plasma, the low transmission of heat deep into treated material etc.

The process of solid dental tissues destruction was investigated. The represented experimental results have shown effectiveness of this technology on a comparison with now priority results on using of the German «Kavo» laser stomatological instruments, based on temperature action of the Er-laser pulses on dental tissues. For the Nd-glass STRML–laser we defined the depth of deleted non-pigment enamel and dentine - up to 50 μm per one pulse. Furthermore forms of craters and high efficiency of solid dental sedimentations process distraction are determined. It is shown in difference from lasers of the middle infrared range used for these purposes, where there is a problem of the radiation transporting to operating zone, the system on the base of our laser allows to make this with maximum convenience for operator.

[1] Anikeev B.V., Andreyanov V.M., Kozubovskii V.R. USSR Inventor's Certificate no. 716484, *Byul.Izobr.*, no.6 (1980).
[2] Anikeev B.V., Khramov V.N., Levin K.A. *Quantum Electronics*, **26**, 57 (1996).

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ThY7

The use of the Hartley transform for solution of computer-assisted reconstruction problems in laser tomography.

Central problem of laser tomography is the receiving of reconstructed (restored) images of different objects and (or) other information about internal distribution of many physical characteristics from its obtained projective data.

The branch of mathematics engaged with these problems is known as an integral geometry. It based on fundamental generalized projection theorem and predominantly use the complex plane Fourier-like transforms.

In this report we presents the possibilities of using the integral Hartley transform (HT) with the real kernel $cas\xi \equiv cos\xi + sin\xi$ in laser-assisted tomography due to its much better performance according to complex-plane transforms. Hartley transform has two main advantages in contrast to Fourier transform: a) operating with real data fields - HT converts the real input data to real transform domain; b) both-sided symmetry - the forms of direct and inverse HT completely coincides.

Here we propose the practical algorithms based on Hartley transform for solution of reconstruction problems in transactial laser tomography. It have been proved the possibility of application of HT on different stages of processing and filtration of tomographic images.

Paper presents the description of some new methods of image reconstruction based on HT by:

1. linear convolution of projective data with the specially determined function.
2. inverting of projective data with consequent filtration of recieved tomographic image - through 2D convolution (for intensification of higher frequencies).

The aspects of using modified (fast) Hartley transform (FHT) in optical image reconstruction algorithms for improvement of processing performances is discussed.

ThY8

Surface plasmon resonance interferometer for high-sensitivity and wide-range sensing

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Surface plasmon resonance (SPR) is a powerful and widely used method for studies of interfaces and (bio)chemical interactions at them. The common principle of surface plasmon resonance (SPR) sensing is the analysis of the reflected intensity dip versus incidence angle. We have theoretically and experimentally shown that, near optimum conditions, angular dependence of the phase of the reflected wave is step-like and much steeper than that of the intensity.

On this basis, we have developed a SPR interferometer for applications in biosensing, that combines ultra-high sensitivity specific to the phase with dynamic range as wide as in the traditional SPR. By mixing a *p*-polarised signal beam with a *s*-polarised reference one, we visualised the phase "step" as a fringe in an interference pattern where one dimension was angle and the other was *p*-phase relative to *s*-one.

The interferometer was tested for recording antigen-antibody binding in water ambient. Three levels of sensitivity were observed. First, the step moved in the course of binding together with the intensity dip, providing the wide dynamic range. A higher sensitivity was obtained from the slope of the "step". But, a record-high one was achieved when even a minute binding resulted in the inversion of the "step". The interferometer was proved to be robust, immune to noises, and prospective for ultra-high sensitive and wide-range sensing.

LASER CORRELATION SPECTROSCOPY FOR DETERMINING BIOCHEMICAL PARAMETERS OF WHOLE BLOOD

ThY9

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Correlation spectroscopy methods are widely used to study dynamical, morphological and optical parameters of biological objects.

This work makes an attempt to explore these methods (in particular, due to their expressivity) for diagnosting whole blood under normal and pathological states (cardiovascular diseases).

Not only morphological characteristics of blood elements are known to change under diseases, but also its biochemical composition does. However, the biochemical analysis of blood is rather time-and labour-consuming.

The paper is directed to investigating the correlation between optical characteristics of light scattering by blood and its biochemical parameters. Samples of whole blood were *in vitro* investigated for ills with different diagnoses and extend of cardio-vascular diseases as well as for essentially healthy donors.

Simultaneous with the above characteristics, we have monitored concentration of lipoproteides, erythrocytes and haemoglobin. The analysis of obtained results has shown that the width of spectrum is greater for healthy persons then for ills.

Comparison of measured data on frequency spectrum, diffuse reflectivity, biochemical and morphological blood parameters of the studies samples has shown the high correlation between the spectrum halfwidth and concentration of lipoproteides, erythrocyte setting rate. Some poorer correlation with spectrum occurs for concentration of *haemoglobin and cholesterol.*

18:30-20:00 **BLUE HALL**

ThZ - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics

ThZ1

RELATIVISTIC PONDEROMOTIVE FORCES

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The concept of *ponderomotive force* (PF) is well known and has been thoroughly investigated theoretically and experimentally for quite a long time [1-3]. The PF drives many phenomena that occur in scattering by a laser field and particle acceleration experiments. In the existing quantum-mechanical theory, the PF is usually introduced from the single electron Shrodinger equation in the electromagnetic field, averaged over fast oscillations of the field.

In principle, the direct averaging of the Shrodinger equation seems to be not a quite correct procedure due to the fact that the term linear in $\mathbf{A(r,t)}\left(\propto \frac{e}{c}\mathbf{A(r,t)}\hat{\mathbf{p}}\right)$, though being a fast oscillating function of time t, can give contributions δF_{pond} to slowly varying component of the force, acting upon an electron. At non-relativistic electron energies, these contributions represent small relativistic corrections to the PF. But the situation changes dramatically for relativistic electrons, propagating along the laser axes. In this case, δF_{pond} becomes strongly-dependent on the angle between the wave-vector and the electron momentum. The maximal ratio between the PF and δF_{pond} in the plane-focused Gaussian beam reaches $(\gamma^2 - 1)$, where γ is the relativistic factor.

REFERENCES

1. T.W.B. Kibble, Phys. Rev. **150**, 1060, (1966).
2. J.H. Eberly, Prog. Opt. **7**, 359, (1969).
3. R.R. Freeman, P.H. Bucksbaum, H. Milhberg, S. Darrak., D. Schumacher, and M.F. Cencis, Phys. Rev. A **59**, 1092, (1987).

ThZ2

Λ- AND *V*-CHANNELS OF POPULATION REDISTRIBUTION IN RYDBERG ATOMS

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Two kinds of Raman-type transitions, Λ-type transitions via the continuum and *V*-type transitions via lower resonant levels, can be responsible for strong-field-induced redistribution of populations at Rydberg levels. Such a redistribution of populations is associated usually with the field-induced stabilization of an atom. Stabilization means that, in a strong field, the ionization yield per pulse becomes either a falling or, at least, not growing function of the laser peak intensity.

Stabilization due to the Λ-type transitions is known as the interference stabilization [1, 2]. V-type transitions also were considered earlier in the context of stabilization [3, 4]. However, the competition between these two mechanisms of stabilization was not clearly understood, and the results of such an investigation are presented in this report.

Briefly, stabilization of a Rydberg atom can be stimulated by the *V*-type transitions if (i) the frequency of the field ω obeys inequalities $|E_n| << \omega << |E_g|$, where E_n and E_g are the energies of some Rydberg and the ground atomic levels; (ii) resonance conditions with a lower-energy Rydberg level $E_{n'}$ are provided, $\omega \approx E_n - E_{n'}$; and (iii) the pulse duration is long enough, $\tau >> T_K = 2\pi n^3$, where T_K is the Kepler period.

References

1. M.V. Fedorov and A.M. Movsesian, J. Phys. B, **21**, L155 (1988)
2. M.V. Fedorov, Com. At. Mol. Phys., **27**, 203 (1992)
3. M.Yu. Ivanov, Phys. Rev. A, **49**, 1165 (1994)
4. A. Wojcik and R. Parzinski, J. Opt. Soc. Am. B, **12**, 369 (1995)

ThZ3

OPTICAL TUNNELING AND FINITE MOTION OF AN ELECTRON

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The dynamics of an atomic electron in a strong field of an optical pulse is investigated within the framework of the known "two step" semiclassical model. The second step classical equation of motion of an electron is analyzed in the Kramers-Henneberger approximation, that is with the passage to the oscillating system of coordinates and the replacement of the pulsating atomic potential by its averaged in time value.

Apart from fast (at the radiation frequency) oscillations with a large (as compared to the atomic size) amplitude, an electron emerging from tunneling is involved in a slow motion in the field of the atomic residual. This motion is either finite or infinite, depending on the initial conditions of the appearance of an electron outside of the potential barrier. The fraction of electrons involved in finite motion is evaluated analytically for simple case when the tunneling probability of an electron per pulse is small as compared with unity.

The lower boundary of a high-frequency radiation range where the motion of an electron can be separated into fast and slow components is defined. This boundary depends on the strength of the radiation field and the binding energy of the electron. The corresponding restriction on the radiation frequency is sufficiently weak, so that optical radiation certainly falls within the high-frequency range.

ThZ4

Vibration, Rotation and Dissociation of Molecular Ions in a Strong Laser Field

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Vibration, rotation and dissociation of the simple diatomic molecular Cl_2^+ and H_2^+ ions perturbed by a strong laser pulse with linear polarization are considered in the frames of classical mechanics. It is found that the duration of the laser pulse influences the rotation of the molecular axis and the vibration of the internuclear separation. The molecular axis of the heavy molecular ion Cl_2^+ is strongly rotated after the end of the ultrashort laser pulse, while the alignment of the H_2^+−ion axis occurs in the rise of the long laser pulse due to quick dissociation. Angular distributions of protons in dissociation of H_2^+−ion are calculated.

Previous paper of the authors [1] was devoted to the problem of vibrations and dissociation of hydrogen and deuterium molecular ions in a strong laser field. However, we did not take into account the possibility of induced molecular rotation in the process of dissociation. Here we give results of numerical calculations for molecular ions of Cl_2^+ and H_2^+ where both rotation and vibration and dissociation can occur. These results are compared with the experimental data by *Normand* group [2] and *Chin* group [3]. The classical mechanics is applied everywhere due to large masses of molecular ions and high laser intensity. The thermal rotation is needed to take into account in the case of H_2^+ ion. Calculations have been made for the finite durations of laser pulse (ultrashort in Ref. [2] and long in Ref. [3]). It should be noted that in experiments with neutral diatomic molecules having the identical atoms first the ionization occurs, since their dissociation is impossible, as a rule. Therefore we consider dissociation of the molecular ions after ionization of neutral molecules by a strong laser pulse.

References

1. M.E. Sukharev, and V.P. Krainov: Laser Physics, **7**, 803 (1997).
2. D. Normand, S. Dobosz, M. Lezius, P.D'Oliveira, and M. Schmidt: in *Multiphoton Processes*, 1996, Conf., Garmisch-Partenkirchen, Germany, Inst. Phys. Ser. No 154 (IOP, Bristol 1997), p.287.
3. F.A. Ilkov, S. Turgeon, T.D.G. Walsh, and S.L. Chin: Chem. Phys. Lett., **247**, 1 (1995)

ThZ5

ABOVE-THRESHOLD ELECTRON RESCATTERING IN SUPERSTRONG LASER FIELD

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Laser radiation of relativistic intensity ($I \sim 10^{18}$ W/cm^2, $\lambda \sim 1$ μm) is now available that stimulates an activity in experimental investigations of relativistic features of above-threshold photoelectrons evolution. Here we study the spatial distribution of above-threshold photoelectrons produced during the tunnel ionization of multicharge ions. It is shown that the essential modification of this distribution should be due to simultaneous influence of relativistic effects and Coulomb interaction on electron motion in the continuum. In the case of quite strong pump field (when Keldysh parameter $\gamma << 1$) electrons born at the time moments that are symmetric about laser field maximum ("symmetric" electrons) contribute to practically the same azimuthal angle θ of spatial distribution. At $\gamma \leq 1$ evolution of such electrons becomes considerably asymmetric due to Coulomb rescattering of electrons near the parent ion. The distinction in evolution of "symmetric" electrons depends essentially on the duration of laser pump pulse. In the short pulse, the gradient force on the trailing edge of the pulse leads to suppression of relativistic forward displacement of electron away from the parent ion and favors electron rescattering, so the difference in "symmetric" electrons evolution becomes more pronounced. Additionally, in this case there is a large number of backscattered electrons which form an additional (backward, $\theta > 90°$) peak in spatial distribution (Fig.). Position of the forward peak does not change essentially with the parameter γ decrease due to the suppression of relativistic drift. Our calculations show that angle difference between forward and backward peaks could reach the value of 10°-15°. This difference decreases with: (1) laser radiation intensity growth (Fig.), (2) laser radiation elliptisity growth, (3) decrease of the initial charge of the ions in interaction volume.

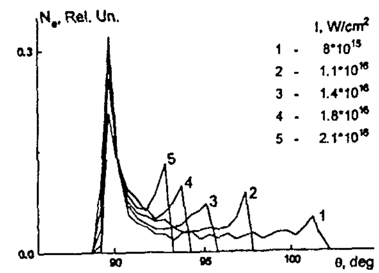

Fig. Number of electrons N_e produced during tunnel ionization of Ar^{8+} ions by elliptically polarized ($\alpha = 0.04$) laser radiation with pulse duration 100 fs, $\lambda = 1$ μm and different peak intensity I.

This work was supported by RFBR (grant No. 98-02-17525-a).

THE REVIVAL BEHAVIOUR OF IONIZATION PROBABILITY FOR 3D HYDROGEN ATOM IN A LINEARLY POLARIZED STRONG LASER FIELD

ThZ6

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The dynamics of 3D Hydrogen atom in a linearly polarized laser field is investigated by means of direct numerical integration of nonstationary Schrödinger equation.

The obtained probability of ionization is shown to demonstrate a nonmonotonous dependence on the peak laser intensity value. The minima of ionization are found to take place in the case of multiphoton resonances between initial ground state and one of excited bound states, the Stark shifts of the energy levels being taken into account.

The reason for the stabilization-destabilization regions observed is likely very similar to that discussed in analytical work [1]. Such a stabilization is shown to result from population trapping due to Λ-type Raman transitions between resonant excited state and the neighboring states via the continuum. The revivals are seen to appear if the laser field is strong enough and Λ-type transitions seem to be efficient. The repopulation of different bound states during laser pulse is investigated and the significance of field-induced Λ-type transitions for the stabilization is established. It should be mentioned that quite similar mechanism was found to result in stabilization observed in experimental [2] and numerical [3] investigations of rare gases ionization in an intense laser field.

References.

1. Yu.V.Dubrovsky, M.Yu.Ivanov, M.V.Fedorov, ZhETF, 99, 411, (1991)
2. A.Talebpour, Y.Liang, and S.L.Chin, J.Phys.B, 29, 3435, (1996)
   A.Talebpour, C-Y.Chien, and S.L.Chin, J.Phys.B, 29, 5725, (1996)
3. O.V.Ovodova, A.M.Popov, and O.V.Tikhonova, JETP, 85, 257, (1997)

Tunnel Above-threshold Ionization, Photoelectron Rescattering and Generation of Short-wavelength Radiation by Atoms with Complex Laser Field Pumping

ThZ7

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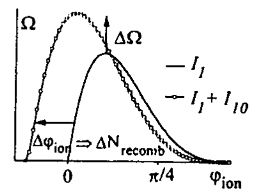
Due to the progress in the technique of high-order harmonic generation (HHG) coherent short-wavelength radiation by atoms in strong laser field has begun to be used in a number of applications. Therefore the problem of HHG efficiency enhancement becomes essential. To enhance HHG efficiency we suggest to use pump radiation of complex structure [1], e.g. to combine strong radiation of wavelength $\lambda \sim 1$ μm and a relatively weak field of $\lambda \sim 10$ μm. This effect can be understood clearly in terms of simpleman's theory. The long-wavelength field modifies the electron trajectories in the continuum, so an increase should be observed in:



(1) the number of recombining photoelectrons N_{recomb};

(2) kinetic energy of such electrons (Fig.). We confirm this effect by a number of numerical calculations of harmonic spectra performed in the frame of unified approach [2] that takes into account relativistic effects and Coulomb electron-ion interaction as well as ionization saturation. The increase of the electron kinetic energy leads to extension of the harmonic plateau, while the increase of the number of recombining electrons ensures the growth of harmonic intensity near the cut-off frequency Ω. The calculations show that adding a long-wavelength radiation with intensity I_{l0} only 1% of that of the fundamental radiation (I_l) could lead to the increase of Ω by 30 %. Note that adding of long-wavelength radiation doesn't result in a considerable growth of the total number of photoelectrons, so an additional depletion of atomic states will not occur. Further optimization of harmonic generation by atoms with two-color pump fields could be achieved by using elliptically polarized radiation.

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1. N.Yu. Shubin *Proceedings of the 15th Conference on Fundamental Atomic Spectroscopy (FAS-XV)*, p.29 (Zvenigorod, Russia, 1996).
2. R.V. Kulyagin, V.D. Taranukhin. *Quantum Electronics*, 26, pp. 866-870 1996.

ThZ8

Hot Electrons in the Tunneling Ionization of Atoms

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A compact generalization of Landau-Dykhne approach [1] is derived for the ionization rate that includes rescattering analytically. It is used for calculations of energy spectra of hot electrons for tunneling ionization of atoms at high intensity by low-frequency laser radiation. Most of the essential features of recent measurements [2] are reproduced, that is, the onset, the extent, and the relative height of the plateau, which makes up the major part of the observed energy spectrum.

Landau-Dykhne method [1] is based on a knowledge of the classical energy $E_l(t)$ of the ejected electron as a function of time. This energy was derived for an electron which is ejected from the atom with nonzero initial velocity. This electron can return back to the atomic core. After rescattering it goes to infinity, but his kinetic energy $E_2(t)$ is given by another function of time. The ionization rate is given by the simple expression (with exponential accuracy)

$$w = \exp\left\{-2\,\mathrm{Im}\int_0^{t_{1,2}}\left[E_{1,2}(t) - E_0\right]dt\right\},$$

where the classical complex turning points $t_{1,2}$ are derived from the equations $E_{1,2}(t_{1,2}) = E_0$, and $E_0 < 0$ is the initial bound energy of the considered atom.

The obtained analytical results are in good agreement with results of numerical calculations [3], including the classical cutoff of the electron energy spectrum at $10U_p$ (U_p is the electron ponderomotive energy).

We are grateful to Russian Foundation for Fundamental Research for partial support (grant N 96-02-18299).

References

1. N.B. Delone, V.P. Krainov: *Multiphoton Processes in Atoms* (Springer, Berlin-Heidelberg 1994), Section 4.1
2. B. Walker et al.: Phys. Rev. Lett. **77**, 5031 (1996)
3. A. Lohr, M. Kleber, R. Kopold, W. Becker: Phys. Rev. A **55**, R4003 (1997).

ThZ9

Multiphoton ionization of molecules under strong field perturbation of Rydberg states

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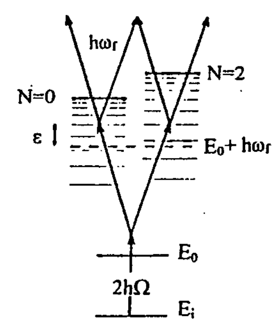
Multiphoton ionization of molecule H_2 with participation of Rydberg $np(0)$ and $np(2)$ series of the $R(0)$-optical branch (where $N = 0$ and $N = 2$ rotational states are mixed by nonadiabatic coupling [1]) is investigated. The (2+2)-scheme of ionization induced by a weak field (with frequence Ω) and by intense monochromatic radiation (with frequence ω_f) is considered (see Figure). The wave functions of continuous spectrum have been defined with taking into account field-induced mixing of many groups of states and expressed in terms of elements of the **T**-matrix of radiative collisions [2]. Photoelectron spectra and dependence of positions and widths $\Gamma_n = \gamma_n(f)/n^3$ of Rydberg levels on the principal quantum number n and electric field strength f are found. We analysed the following region of spectrum $|\varepsilon| \gg 1/n^3$, where energy ε of bound weakly electron (measured from quasilevel $E_0 + \hbar\omega_f$) exceeds substantially the distance between Rydberg states in the channel $N = 0$. It is shown that the field perturbated energy levels and widths are defined as the solution of equation which is analagous at $\gamma_n(f) \to 0$ with the two-component Fano equation [1]. Its matrix elements are controlled on value by external field. The function $\Gamma_n(f)$ is non-monotonic substantially, i.e. it increases sharply $\Gamma_n(f) \sim A_n f^2$ at $\xi = \frac{f^2|E_0|^{3/2}}{\omega_f^{10/3}\varepsilon} \ll 1$, decreases weakly at $\xi \sim 1$, and inctreases smoothly $\Gamma_n(f) \sim B_n f^2$ at $\xi \gg 1$ (where coefficients $B_n \ll A_n$). It differs remarkably from occuring dependence on f for hydrogen atom and simple atoms with structureless core [2].



1. Fano U. Phys.Rev. **2** 353 (1970)
2. Ivanov G.K., Golubkov G.V., Manakov D.M. JETP **79** 707 (1994)

ThZ10

ELECTRON DETACHMENT FROM NEGATIVE IONS IN TWO-COLOUR LASER FIELD

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Negative ion detachment in two-colour laser field is considered within the recent modification [1] of the Keldysh [2] model which makes it quantitatively reliable. The calculations are very simple technically, essentially consisting of search for the stationary phase points (as roots of a polynomial) and evaluating an analytical expression at each of these points and summing over all stationary phase point. Physically the summation accounts for interference effects which are responsible for the structure in the angular dependencies of rates. The general approach is illustrated by calculation of angular differential detachment rates, partial rates for particular ATD (Above Threshold Detachment) channels and total detachment rates for H^- ion in bichromatic field with 1:2 frequency ratio when electric field in the light wave is presented as $F(t) = F_1 \cos(\omega t) + F_2 \cos(2\omega t + \delta)$. In this case the differential rates are known to exhibit polar asymmetry which depends on the difference of the field phases δ and turns zero for $\delta = 0$. Both perturbative and strong field regimes are examined. Polar asymmetry and phase effects are quantitatively characterized with some new features revealed. In the perturbative regime the polar asymmetry is appreciable for the lowest ATD channel and rapidly grows for higher ATD peaks. In the strong field case the asymmetry has comparable magnitude for all ATD channels. The total detachment rates (summed over all ATD channels) remain fairly insensitive for the phase variation. The calculations for 1:3 frequency ratio are in progress and will be presented at the conference.

[1] G.F.Gribakin and M.Yu.Kuchiev, *Phys. Rev. A* **55**, 3760 (1977); *J. Phys. B* **30**, L657 (1997).
[2] L.V.Keldysh *Zh. Eksp. Teor. Fiz.* **47**, 1945 (1964) [*Sov. Phys.-JETP* **20**, 1307 (1965)].

ThZ11

Focusing of High-Order Harmonics Generated by Two Coaxial Beams.

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High-order harmonic generation (HOHG) by two coaxial exiting gaussian beams is discussed. The intensities and focusing lengths of the beams are close to each other, the beams are directed along the same axis and focused at the different sides of the target. Generated in this scheme harmonics occur tightly focused at different distances from the target. The effect is treated quantum mechanically and classically. Calculations show the harmonic intensity in the waist can be about order of magnitude higher than the sum intensity of other HOH-s and several times higher than the third harmonic intensity. The effect can be used for:

a) selecting a single harmonic by means of a diaphragm located in the waist of the harmonic beam. This selecting is not effective for harmonics close to the high-frequency edge of a plateau.

b) obtaining a high-intensive short wave-length coherent field.

Also the possibility of phase matching while HOHG using two coaxial exiting gaussian beams is discussed.

ThZ12

High-Order Harmonics Generation by Bichromatic Field.

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Theory of high-order harmonic generation (HOHG) by bichromatic field is developed. The analytical formula for complex amplitudes of combined high-order harmonics is derived. The formula contains three-dimensional sum. The last can be reduced to the one-dimensional one in particular cases.

Simulation of combined high-order harmonics generated by exiting fields with frequencies ω and $n\omega$ (n=2,3 and others) is carried out. The results show that the exiting field with the frequency $n\omega$ provides significant increasing intensity of some harmonics. It corresponds to the experimental results [1,2]. The origin of the effect is discussed.

The possibility of phase matching of harmonics under bichromatic excitation is also discussed. It is shown that the phase matching can be provided under changing electron number density if one of the exiting frequencies significantly exceeds the other.

[1] M.D.Perry, J. Crane, Phys. Rev. A, **48**, R4051 (1993).

[2] S. Watanabe, K.Kondo, Y. Nabekawa et. al., Phys. Rev. Lett, **73**, 2692 (1994).

ThZ13

THE COHERENT EFFECTS IN THE PROCESS OF HIGH HARMONIC GENERATION

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Resently in the experimental work of Lund-Saclay group [1] was investigaited the dependence of high harmonic generation (HHG) intensity on the atomic beam density. In the case of moderate densities (4 – 14 mbar) the intensity of HHG was established has the quadratic dependence with the atomic density. But this dependence saturates and after a threshold density does not increase. The threshold density depends on the harmonic number and the power of the pump wave.

In the paper presented the analytical quantum approach [2] is applied to describe qualitatively the effects observed in [1]. The multiphoton exitation of atom by the pump wave following by one quantum recombination to the ground state is considered. Thus the HHG is connected with the above-threshold ionization (ATI) process. The phase matching of emission amplitudes is taken into account. The quadratic dependence of HHG intensity with the atomic density is shown to be observed when the phase matching coherence length is larger than the diameter of atomic jet. The HHG intensity is going to be constant when the coherence length becoms smaller than this diameter.

To take into account the space dependence of focused laser light the simple model is proposed. By the use of this model the dependence of threshold density with the high harmonic number and the laser power is estimated. The comparison with experiment is presented.

[1] C.Altucci, T.Starczewski, E.Mevel, C.-G.Wahlatrom, B.Carre and A.L'Huillier. J. Opt. Soc. Am. B. V.13, P.148, 1996.
[2] D.F.Zaretsky and E.A.Nersesov. Zh. Eksp. Teor. Fiz. V.109, P.1994, 1996.

ThZ14

NONLINEAR EVOLUTION OF INTENSE LASER PULSES IN FIELD-INDUCED IONIZATION PROCESSES

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The report is devoted to the investigation into the dynamics and structure of the field and field-created plasma in optical-field-induced ionization processes produced by the laser pulse of super-high intensity ($10^{14} - 10^{18} W/cm^2$). Based on the theoretical analysis and computer simulation, we have found and analyzed three groups of new nonlinear effects inherent in the ionization processes considered and not taking place for the so called "focusing nonlinearity" mechanisms (ponderomotive, relativistic, etc.).

The first group of effects concerns the time-spectrum transformation of radiation in the ionization processes. We have studied the nonlinear spatio-temporal evolution of the focused fs laser pulse and the plasma produced by the pulse itself due to tunneling gas ionization. The computer simulation on the basis of exact 2-D wave equation allowed to predict and describe the high self-blueshifting effect (the frequency shift is order of 100%) and formation of short leading peaks of the field (half-wave ionizing "leaders").

Effects of the second group consist in formation of the self-sustained plasma waveguides with a free boundary, that confine the slow surface wave and can provide the directed transfer of radiation and ionization for a long distance. We have found two types of possible self-channeling ionization structures : (i) the thin overcritical plasma layer, supporting the slow surface wave; (ii) the sharp-bounded ~~wide~~ plasma waveguide supporting, at saturable ionization, the fast wave with a slight leakage.

The third group includes the effects caused by the plasma-resonance ionization instability. The laser field amplitude and plasma are found to be unstable in plasma creation process relative to spatial modulation in the direction of laser electric field with the period small as compared to the wavelength. In a solid or dense gas the process, at the nonlinear stage of instability, goes on in the sharpening regime and leads to the formation of long lifetime microstructure with electric field concentrated into thin plasma layers. Such a structure can provide the transparency of the dense breakdown plasma and probably was realized in the recently published experiments on transmission of 30 fs intense laser pulse through solid-density laminar plasma.

The effects considered change drastically the characteristics of plasma and field interaction and they are of importance for applications connected with the creation of dense laser plasma, such as the diagnostics and conversion of ionizing laser pulse spectra, the creation of x-ray lasers, particle acceleration in plasma, and efficient XUV harmonic production.

ThZ15

EFFECT OF THE ANTI-STOKES SCATTERING ON THE STIMULATED RAMAN GAIN IN PLASMA

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The modern investigations on the laser fusion make it actual to search physical factors, which have effect on the Raman gain in plasma. We believe that one of such factors can be anti-Stokes scattering. It is well known that the anti-Stokes scattering in a molecular medium can essentially reduce the Raman gain. Is the similar effect possible in plasma, and is it possible to suppress the SRS in plasma by increasing intensity of the pumping radiation? This paper is devoted to solving these questions.

Taking into account the anti-Stokes scattering, we have obtained the following expression for the Raman gain in a homogeneous plasma:

$$\Gamma = \Gamma_0 \mathrm{Re}(1-\mu)^{1/2}$$

Here Γ_0 is the Raman gain in the absence of the anti-Stokes component, the parameter μ is determined by the plasma density and temperature as well as by the frequency of the pumping radiation, but not by the pumping intensity. A straightforward expression for μ is given in ref.1. The formula for Γ is obtained with using of the plane-wave approximation and the given field of pump approximation for the steady-state regime of the SRS and for sufficiently high pumping intensity. Note that generally $\Gamma < \Gamma_0$, i.e. the anti-Stokes scattering reduces the Raman gain in plasma.

We have estimated the value of the parameter μ for the following conditions closed to conditions of the laser fusion: the plasma temperature 1 keV, wavelength of the pumping laser radiation 0.5 μm, frequency of the Stokes component of the SRS is equal to half frequency of the pump. For these conditions the parameter μ was found to be 0.03. Thus, the effect of the anti-Stokes scattering on the Raman gain in plasma is found to be rather weak.

In conclusion, we have analyzed the effect of the anti-Stokes scattering on the Raman gain in plasma in conditions of the laser fusion. It has been shown that the anti-Stokes scattering generally reduces the Raman gain, but the correction to the gain is relatively small, and for the limit of intense field of pumping it does not depend on the intensity of the pumping radiation.

References

1. Bilak O.M., Nikitin S.Yu. Vestnik Moskovskogo Universiteta. Seriya: Fizika, Astronomiya, 1997, N 5, p. 40.

ThZ16

A NEW TECHNIQUE FOR SUPPRESSING OF STIMULATED RAMAN SCATTERING IN PLASMA OF THE LASER FUSION - FAST FREQUENCY MODULATION OF THE PUMPING RADIATION

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The problem of suppression of the stimulated Raman scattering (SRS) and stabilization of a powerful laser beam in plasma is one of the actual problems in the modern investigations of the laser fusion. To solve this problem we suggest to use a fast frequency modulation of the pumping radiation. Considering an inhomogeneous plasma and a pumping with linear frequency modulation (LFM), we obtain the following expression for the Raman gain

$$G = G_0/[1 + 2\beta\nu/(\kappa' V_P)].$$

Here Go is the gain corresponding to the monochromatic pumping (i.e. to the pumping of the same power, but in the absence of the LFM), β is the rate of the frequency modulation, $\nu = 1/V_l - 1/V_S$ - is the mismatch of the group velocities of the pumping laser wave and the wave of the Stokes component (for the backward scattering $\nu = 2/c$, where c is the velocity of light), κ' is a parameter proportional to the gradient of the plasma density, and V_P is the group velocity of the electron plasma wave. The formula obtained indicates a principal possibility to suppress the SRS by using the LFM of the pumping radiation. The mechanism of the suppression is connected with a fast displacement of the point of synchronism, in vicinity of which the process of SRS is the most effective. This leads to effective increase of the plasma inhomogeneity and, as a consequence, to effective decrease of the amplification length and the Raman gain.

We have estimated the value of the Raman gain G for the following conditions closed to conditions of the laser fusion: the plasma temperature 1 keV, wavelength of the pumping laser radiation 0.5 μm, frequency of the Stokes component of the SRS is equal to half frequency of the pump. The plasma density was approximated by a linear function of coordinate, the target size was taken 1 mm. The estimate shows that in these conditions it is possible to decrease the backward Raman gain twice, providing the rate of the frequency modulation as high as 2 % per 1 picosecond. The modulation required can be obtained in a train of picosecond laser pulses or in the nanosecond laser pulse without changing of its mean frequency by using the frequency modulation of the saw-toothed form.

References

1. Bilak O.M., Nikitin S.Yu. Vestnik Moskovskogo Universiteta. Seriya: Fizika, Astronomiya, 1996, N 4, p. 64; N 5, p. 40.

ThZ17

ELECTROMAGNETIC INSTABILITY IN RELATIVISTIC SOLID-STATE PLASMA WAS GENERATED UNDER INFLUENCE OF A ULTRASHORT INTENSE LASER PULSE

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The new generation of lasers with powers exceeding the terawatt level and with the pulse duration exceeding the femtosecond range have opened up new possibilities for studying laser mater interaction physics [1],[2]. The action of laser pulses with this intensity and duration on a matter produces nonequlibrium anisotropic solid-state plasma with relativistic electrons. According to theoretical models intense quasi-static magnetic field may be generated in this plasma. In this work it was investigated the influence of relativistic temperature and intense magnetic field on the electromagnetic instability of Weibel type, which is one of the most reasons of turbulence structure in relativistic electron continuum. Using a self-consistent set of Maxwell and Wlasov equations the conditions of appearance of this instability have been established. It was shown that the intense quasi-static magnetic field may be stabilize electromagnetic instability in relativistic anisotropic plasma. A new type of beam instability in nonisothermal relativistic anisotropic plasma was found, which has not analogy in nonrelativistic case.

1. Gamaly E.G. 1994, Laser and Particle Beams, 12, 185.
2. Arefyev V.I. and Beliaev V.S. 1995, Laser Physics, 5,856.

ThZ18

Charge-transfer pumping of laser-produced plasma on vapor cloud for lasing in XUV

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In the late 70-s a charge-transfer pumping of high-Z laser-produced plasmas on neutral gas was proposed [1] and experimentally investigated [2]. An inversion of population for various ions was demonstrated, but the efficiency of the process reached in the experiments was less then 10^{-3} of maximum possible level due to photo-ionization and generation of blast wave which prevents an effective penetration of ions into neutrals. In [3] a way to overcome this obstacle has been suggested. The idea was to use, instead uniform gas atmosphere, a compact neutral cloud created by a low-intensity laser irradiation of a solid target.

In this work the results of the first experimental realization [4] of proposed scheme and the investigation of basic physical aspects of charge-transfer interaction and pumping at high densities are presented. The compact cloud of H/C - neutrals was produced by vaporizing the perlon cylindrical target by a $3\mu s$ impulse of CO_2-laser and was characterized by an exponential profile with the scale $0.25\ cm$ and densities in the range $10^{17}-10^{14}\ 1/cc$ on the distances $1-2.5\ cm$ from the target. The flow of C^{+4} ions was generated by irradiation of the planar perlon target by the second CO_2-laser beam of $100\ ns$ duration and $100\ J$ of total energy. The intensity of charge-transfer process between C^{+4} ions and H^{o}, C^{o} atoms of cloud was determined by measuring the absolute luminosity in the line $5801\ A$ of $3s-3p$ transition of C^{+3} ion. The instant spatial structure of interaction was obtained by short-time imaging. Also, a flux of VUV-photons in the range $10-50\ eV$ from the interaction region was measured by means of a collector of secondary photo-electrons.

The results obtained showed that the interaction was mainly of charge-transfer character uninfluenced by rival process of electron heating and ionization. The charge-transfer luminosity of C^{+3} ions had a spatial form of a thin ($<1\ cm$) sheath with very sharp boundaries. The absolute intensity of this luminosity points that the interaction with densities $5\cdot10^{14}\ 1/cc$ of ions and $5\cdot10^{15}\ 1/cc$ of atoms has been achieved with effectiveness of charge-transfer pumping $>10\%$. The measured flux of VUV-photons was in agreement with that in the lines of $2p-3d$, $2s-3p$ and $2p-3s$ transitions of C^{+3} ions.

Thus, a practical possibility of charge-transfer pumping at the densities 10^16 1/cc which are necessary for lasing in lithium-like C^{+3} ion has been experimentally demonstrated for the first time. The next logical step, which we plan to carry out in future experiments, is to use a flow of O^{+6} ions so as to pump $4f$ (instead of $3p$) level of O^{+5} ion and to increase the ion flux in the interaction region up to $10^{16}\ cm^{-3}$. A 3-D numerical simulation performed for mentioned above conditions predicts a gain $>1\ 1/cm$ on the $\lambda = 520\ A$.

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1. Vinogradov A.V. and Sobel'man I.N., Sov. Phys. JETP, 36, p.1115 (1973)
2. Dixon R.H. and Elton R.C., Phys.Rev.Lett., 38, p.1072 (1977)
3. Shaikhislamov I.F., Zakharov Yu.P. Proceed. 23rd Europ. Conf. on Laser Interaction with Matter (Oxford, 1994): Inst. Phys. Conf. Ser. N140, Sect.9, p.403 (1995)
4. Antonov V.M., Zakharov, Yu.P., Ponomarenko A.G., Posukh V.G., Melekhov A.V., Shaikhislamov I.F. Abstracts of Intern. Symp. "Modern problems of laser physics", Novosibirsk, P1 43-44 (1997)

ThZ19

Surface plasmon-polaritons at the diffused boundary of a plasma created by intense ultrashort laser beam

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Summary

In this paper we investigate surface plasmon-polaritons propagating at the boundary of a high-density near-surface plasma produced by intense femtosecond pulses. We have found here numerically using multilayer technique (1) the dispersion characteristics of SPP at the diffused plasma boundary. We neglect the hydrodynamic expansion during the wave propagation time and suppose that plasma has local dielectric function. Collisional and resonance damping both have been taken into consideration. Based on the performed calculations we have set the limits of sharp boundary approximation. It has been shown that the region of application of this approximation corresponds to extremely short times of a plasma expansion (tens of femtosecond). Also the appropriate conditions of direct excitation of surface waves in the case of fuzzed plasma boundary have been found. The advantage of using specific plasma density profiles with the 'pedestal' in subcritical density region have been shown. Analytical dispersion relation in the case of a sharp boundary has been obtained tacking into account spatial nonlocality of dielectric function. Collisions, phase breaking and capacitor heating are neglected. Using obtained relation SPP packet dispersion have been analysed numerically. SPP propagation distance and dispersion length have been compared. It has been shown that for femtosecond SPP duration dispersion length can be less or more than propagation distance depending on plasma temperature and a target material. Nonlinear two-beam excitation of surface plasmons at the sharp plasma boundary has been investigated in hydrodynamic approach. Collisional damping of SPP has been taken into account. In this limits analytical expression for excited SPP electromagnetic field has been obtained. Based on developed analytical technique the estimates of nonlinear SPP excitation efficiency have been done.

[1] S.A.Magnitskii, V.T.Platonenko, A.V.Tarasishin, Conf. *on Superstrong Field in* Plasma, Varenna, Italy, 1997, Abstracts.

ThZ20

Temperature enhancement in a plasma heated by a high intensity IR laser as a result of preirradiation of a metal target by a UV laser pulse

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We have proposed and developed a novel approach to irradiation of targets (two frequency UV&IR irradiation) to produce near-keV laser plasma. According this approach two laser pulses interact consequently with a target. The first (UV) laser pulse creates a relatively dense plasma and the second (IR) pulse interacts with such a preliminary created plasma.

Using this UV&IR irradiation approach, e.g. employing 30-ps UV pulse (at wavelength of λ = 266 nm) providing the laser irradiation intensity on the target I_{UV} of up to 10^{12} W/cm^2 and 30-ps IR pulse (at wavelength of $\lambda = 1.06$ μm) with the intensity I_{IR} of up to $2\cdot10^{14}$ W/cm^2 acting in (0 ... 6) ns after the UV pulse, the following results has been achieved:

1. Using UV prepulse the electron temperature of a plasma was increased by 5 times as compared with the temperature obtained using the single frequency IR irradiation of the same $I_{IR} = 2\cdot10^{14}$ W/cm^2, i.e. from $T_e = 150$ eV to $T_e = 750$ eV.
2. The optimal delay between UV and IR pulses was found to be ~2 ns.
3. The electron temperature grows linearly with the IR pulse intensity at least up to $I_{IR} = 2\cdot10^{14}$ W/cm^2. The temperature enhancement due to UV prepulse is saturated at UV radiation intensity of $\sim 4\cdot10^{11}$ W/cm^2.
4. The effect of electron temperature enhancement falls down when the pressure of ambient air is grown up from $4\cdot10^{-2}$ Torr. The enhancement effect vanishes practically when the air pressure exceeds 2 Torrs.

ThZ21

TERAWATT FEMTOSECOND LASER PULSE TEMPORAL SHAPING USING DOUBLE-STAGE NON-LINEAR OPTICAL CONVERSION

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Pulse duration, rise time and contrast ratio of advanced subpicosecond MultiTeraWatt laser (MTWL) are highly important, since they determine mainly the physical phenomena taking place at laser-solids interaction. In comparison with other state-of-art MWFL, Nd-glass system are leading in the output energy, but has rather long pulse (~500 fs). Even if the contrast ratio of specially designed CPA glass laser can reach high values of about 10^{-9} [1], further studies are to be done to find out new reliable methods for achieving high contrast and stable pulse shape. Stimulated Raman Amplification is an extremely promising way to improve temporal characteristics of MTWL pulses [2]. In this paper we report on the modelling and first experimental results of a double-stage non-linear conversion scheme allowing a pulse shortening of a 10 J Glass-MTWL pulse down to 200 fs with intensity rise time of 100 fs for 2 order of magnitude and prepulse suppression down to quantum noise level. Proposed system consists of (i) second harmonic generator using KDP crystal and (ii) transient Stimulated Raman Amplifier with CH_4 media.

The KDP crystal thickness is limited by phase modulation. For 1.5 mm crystal 700 fs pulse with energy conversion efficiency up to 75% could be obtained [3]. Subsequent Stimulated Raman amplification (SRA) provides stokes pulse with duration of 160±40 fs and energy efficiency 20±2 % (due to 10% seed energy instability) for the gas pressure of 15 atm. The result on SRA were obtained using 1D transient code [2]. For all calculations we tried to keep maximum non-linear phase shift below π.

[1]. M.P. Kalashnikov, P.V. Nickles, Th. Schlegel et.al., Phys.Rev.Lett. 73,2,260 (1995).
[2]. M.S. Dzhidzhoev, et.al., Laser Physics, **6**, 963 (1996).
[3]. Technical Digest of CLEO'97 Conference. Baltimore, May 18-23 (1997).

ThZ22

XUV SPECTROSCOPY AND COUPLING EFFICIENCY OF LASER PLASMA FORMED BY PICOSECOND PULSES ON SOLID MOLECULAR TARGETS

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It was recognized recently that cluster-structured solid targets can provide essentially increased coupling of intense laser pulses energy. We study XUV yield increase due to specific intracluster processes in an intense field. Big molecules, such as metal-phthalocyanines and fullerenes are under investigation. Metal ions encaged in the center of phthalocyanine molecules can produce effectively multi-charge ions in the laser plasma due to high intramolecular electron density, free electron effective formation and heating.

The targets are prepared by coating of metal-free, copper, and lead phthalocyanines, as well as from tungsten, aluminum, and carbon. Moderate power nanosecond and picosecond neodymium lasers are used to produce 10^{11} to 10^{13} W/cm^2 of incident intensity on the targets. The laser plasma temperature and electron density are measured by recording intensities and spectral widths of the ion lines in a broad spectral region from 40 to 300 nm with a resolution of less than 0.05 nm. To date we have observed and analyzed more than ten lines including Al^{3+} at 76.8 nm, Al^{2+} at 56 nm, C^{3+} at 253 nm, C^{2+} at 29.7 nm. The measurement technique permits us to determine the electron density and temperature dependence on the distance from the target surface to up to ~ 5 mm, where $N_e \geq 10^{17}$ cm^{-3}. For example, for an aluminum plasma at a distance 1 mm from the target $N_e = 2.0(\pm 0.5)10^{18}$ cm^{-3} and $T_e = 14$ eV, respectively.

Preliminary experiments show that the conversion efficiencies for the molecular targets are more than an order of magnitude greater than those measured from bulk solid metal targets. Different types of coatings are currently under investigation.

ThZ23

Generation of 100-KeV γ-Rays with a Picosecond Laser

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γ-rays registration was carried out from laser produced plasma which had been created on the solid beryllium targets having the thickness of 1.8 mm by the individual pulse of Nd-glass laser radiation with the following parameters: pulse energy 1 J, wavelength is 1.06 mkm, pulse duration is 1 picosecond. The laser radiation was focused onto the target with the help of the spherical lens with the focus distance of 15 cm into the spot with 100 mkm in diameter providing the falling radiation intensity of about 10^{16} W/cm^2.

The radiation detectors with stilbene crystal in a form of disks having the sizes of 5x5 cm and 6.3x2 cm were situated at the distance of 2 and 10 cm from the target under the angle of 90 degrees to the falling laser radiation correspondingly.

The detectors were arranged outside the vacuum chamber (the pressure in the chamber was 0.01 Torr). They were enclose in a 1.5 mm wall thickness aluminum tubes. The detectors were situated close to the aluminum vacuum chamber windows with the thickness of 2 mm. Such a protection from aluminum with the total thickness of 3.5 mm permitted to remove X-rays below 10 KeV.

Two methods of γ-rays registration were used: with the help of coincidence circuit and two-channel C8-14 oscillograph.

Filters made from lead having the thickness of 1.2 mm and from aluminum having the thickness up to 30 mm were placed before the first detector. The second detector was used to monitor X-rays and γ-rays for each shot. The detectors were calibrated with the use of Cs^{137}, which is the radioactive source of γ-rays.

The use of lead and aluminum filters in front of the first detector permitted to separate the single γ-ray and to measure the maximum energy of γ-ray, which was 100 KeV. The estimation of the maximum energy of γ-rays was carried out also for γ-rays absorption registration in lead and aluminum filters, which was 100 KeV too.

ThZ24

OVERHEATED FEMTOSECOND PLASMA IN HIGHLY POROUS SILICON

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A typical value for the mean electron temperature obtained in femtosecond laser plasma interaction with bulk solid targets does not exceed 1 keV. Under laser radiation intensities in excess of 10^{17} W/cm^2 large amount of the energy absorbed wastes on the production of hot electrons with energies from few keV up to MeVs.

In this paper we show that using nanostructured highly porous silicon as a target one can overheat the plasma under "moderate" intensity of 10^{16} W/cm^2, thus obtaining hard x-ray production above 5 keV and high flux of hot 20-100 keV ions.

In performing experiments on femtosecond laser-plasma interaction we used femtosecond laser system described elsewhere [1], which provides intensity in excess of 10^{16} W/cm^2 with intensity contrast ratio better than 10^5. We measured hard x-ray yield, second harmonic generation, and ion energy spectrum of the plasma formed in electrochemically prepared porous silicon samples with different porosities.

The most striking feature of the data obtained is a dramatic increase in the hard x-ray photon flux if porosity P (ratio of the crystalline silicon density to the porous one) exceeds the value of 5. We attribute this behavior to morphological changes taking place in silicon with porosity increase, namely nanoclusters formation [1]. These changes were investigated using photoluminescence and AFM techniques.

The detailed picture of interaction of superstrong laser field with highly porous s ilicon are discussed, including thermal flux suppression, ion component heating, and efficient hot electron production mechanisms.

1. R.V.Volkov, V.M.Gordienko, M.S.Dzhidzhoev, et al., Quantum electronics, 27, 1081 (1997); 28, 1 (1998).

ThZ25

PROPOSAL FOR THE X-RAY LASER PUMPED BY A POWERFUL SHORT-PULSE -DRIVE LASER

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Presently the technique of chirped pulse enhancement allows the construction of a compact YAG lasers with pulse duration 0.1-1 ps, power more than 10^{15} W and the main pulse to prepulse intensity ratio more than 10^8 [1]. This pulse can be focused on an oblong target; it can drive highly non-equilibrium plasma. This increased efficiency results from the high pulse intensity $I > 10^{14}$ W/cm^2 - because optical field ionization becomes a key mechanism for plasma production and heating . Electron acceleration in the optical field and electron absorption of laser pulse photons are other key processes that drive plasma heating and collisional ionization. Thus high temperature (Te > 3 KeV) high density (ne $>10^{23}$ cm^{-3}) uniform plasma can be created with a proper designed target and drive laser pulse parameters. On the basis of accurate atomic-kinetic model it is shown that large ASE effect is obtainable at these plasma conditions where the Ne-like ionization stage dominates.

Near optimum plasma conditions for lasing in the Ne-like ions are determined based on the accurate atomic-kinetic model. For elements with moderate Z value: $40<Z<60$ the processes of electron recombination on Ne-like ion and ionization of Na-like ion are balanced. Thus the Ne-like ionization stage is steady-state (non-transient). The detailed results for gain calculations are presented for the pure silver plasma. At electron temperature Te =3-5 KeV and density $5\times10^{22} < n_e < 10^{23}$ cm^{-3} the large gain values are achievable: GL > 100 at λ=10.038 nm and λ=12.298 nm. Lasing is also possible at λ=2.75 nm on the innershell 2s-2p transition. This approach has four distinct advantages in compare with conventional experiments with laser produced plasma which use a long lasting (>100 ps) laser drive pulses: I) An improvement in plasma uniformity. II) An increase in the conversion of the input energy to the output laser radiation. III) An increase in the brightness of X-ray laser radiation. IV) A significant increase in the gain values. V) A laser output at shorter wavelength λ=2.75 nm.

1. M.S.Dzhidzhoev, V.M.Gordienko, V.V.Kolchin, S.A.Magnitsky, V.T.Platonenko, A.B.Savel'ev, and A.P.Tarasevich, J. Opt. Soc. Am. B13, 143 (1996).

ThZ26

REQUIREMENTS TO ACTIVE MEDIA OF COHERENT RADIATION SOURCES ON NUCLEAR TRANSITIONS WITH A PLASMA PUMPING

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For a laser-active element (LAE) that amplifiing radiation on nuclear transition, upper working level of which pumped from isomeric state by bremsstrahlung and photorecombination radiation of an external source of pumping (lamp) (active media of the LAE and the lamp is a high-temperature equilibrum laser plasma), resulting expression for a gain coefficient, connecting parameters of a laser-active medium and pumping source is obtained

$$\kappa(E_q,\lambda) = 7\cdot 10^{-7}\cdot\frac{\hbar^2\cdot c^2}{2\cdot\pi}\cdot\frac{M_n\cdot\lambda^3\cdot N_c\cdot N_e^2\cdot A}{E_q^{7/2}\cdot\sqrt{T_g}}\cdot\exp\left(-\frac{2\pi\cdot\hbar\cdot c}{\lambda\cdot T_l}\right).$$

Where λ - wavelength of pumping radiation, cm; E_q - quantum energy of working radiation, eV; M_n - weight of a radiating nucleus, gm; N_c - critical concentration of electrons in LAE, at which the frequency of Lengmure oscillations is compared to frequency of laser radiation, cm^{-3}; N_e - concentration of electrons in a lamp, cm^{-3}; A - radiation probability of a working transition, s^{-1}; T_l and T_g - temperatures of a lamp and LAE accordingly, eV; $\hbar$=6.6·10^{-16} eV·s; c=3·10^{10} cm/s.

For a pumping by Nd-laser with a pulse energy of 1-10 kJ and duration of a pulse 0.1-1 ns (power intensity of the laser varies from 10^{12} up to 10^{14} W/ cm^2); LAE - length of 1 cm and diameter of 10-100 microns; an external coaxial source (lamp) length of 1.2 cm and thickness of 100 microns it is obtained, that: 1 - the wavelength of a pumping transition should not be shorter of 1 nm; 2 - the quantum energy of working transition should not be more than 2 keV; 3 - radiation probability of a working transition should not be less than 10^{10} s^{-1}. In case of creation of enough powerful lasers with a wavelength of 0.35 microns (3-rd harmonics of Nd) of kilojoule range an increase of quantum energy of working radiation up to 4 keV is possible at the about the same requirement to a wavelength of a pumping transition.

ThZ27

Gas-plasma and superlattice free-electron lasers exploiting a medium with periodically modulated refractive index.

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The report aims to determine operation parameters of a compact free-electron laser (FEL) using Media with Periodically Modulated Refractive Index (MPMRI). These media are used for creation of compact sources of visible, UV, or soft X-ray radiation. The amplified electromagnetic wave can interact resonantly with an electron beam traversing the MPMRI via one of the diffracted partial plane waves (PPW) formed incide the medium.

The MPMRI permeability $\epsilon(z)$ was assumed to be STRONGLY modulated according a harmonics law, $\epsilon(z) = \langle\epsilon\rangle + 2\alpha\cos qz$. $2\omega\cdot\alpha(\omega)/qc\langle\epsilon\rangle^{1/2} \gg 1$.

We have determined the maximized gain, the saturation field, and the efficiency of FELs based on various kinds of modulated media. The calculations performed for superlattice-like structure SLL-structure to be composed of KCl and amorphous quartz layers. Its transparency window is $2.8\cdot 10^{15}s^{-1} < \omega < 10^{16}s^{-1}$. The superlattice length $L = 0.5cm$ and modulation period was $\lambda_0 = 3.3\cdot 10^{-3}cm$. The electric current density of the beam was $j = 5\,A/cm^2$. The maximized gain is show in the Figure 1.

It was found that the use of the large-modulation regime makes it possible to extend the operation frequency range of the FEL.

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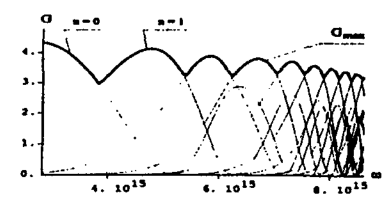

The gain of a superlattice-like FEL operating in the large modulation regime.

ThZ28

THE EXCITATION OF EVEN-EVEN NUCLEI AT THE SUPERSTRONG LASER FIELD

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Summary

It is suggested to use the first quadropole excitatons or 2'+ excitations in the multiply rotation band of even-even nuclei for hard coherent X- or soft γ-rays generation. The active medium can be created by the self-channeling of powerful laser pulses in a gas of light atoms (H, He, Li,...) placed inside a metal tube of γ-lasing nuclei atoms. After removing free electrons from the channel, light ions acquire energies up to several tens MeV, penetrate to the metal tube and excite metallic nuclei by the well-known mechanism of Coulomb collisions. Estimations for nuclei ^{40}Ca and ^{140}Ce show values of γ-rays increment of up to several units per cm.

It is shown that bound charged particle or the group of particles can change their energy under the action of such field, i.e. be excited. The energy obtained by the particles above the bound energy can provide their decay. Thus the direct nuclear excitation and decay by superstrong laser field are possible. Necessary laser intensities to realize the proposed effects are expected as 10^{18} W/cm^2 and more. Nuclear excitations to the bound state are interpreted as induced quadropole ones. They can be realized for large enough numbers of particles in the volume of interaction: up to the one-million part of the particles. It was used for estimations that total laser pulse energy is 1 J and duration is 1 ps.

ThZ29

HYDRODYNAMIC MODEL FOR UV LASER ABLATION OF ORGANIC MATTER

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A hydrodynamic model for UV laser ablation of polymers is proposed. It presents the ablation depth d as a function of laser fluence F, pulse duration τ, and some thermophysical characteristics of the polymer within the region of UV radiation corresponding to the developed hydrodynamic motion of the flame.

The main physical assumptions of the model and the obtained results are the following:

1) For strongly absorbing polymers, the flame formation is considered as a close to equilibrium phase transition (surface "evaporation"). In this case, the ablation boundary coincides with the phase transition interface and the gas phase density $\rho_1 \sim \rho_0 e^{-U/kT}$, where U is the effective activation energy (energy of phase transition),and ρ_0 is the solid polymer density. A satisfactory agreement with experimental data is reached if an adiabatic index of the flame is close to unit. This means that the energy of the evaporated organic matter is mainly concentrated in internal degrees of freedom of ablation products and exceeds the bond energy U which is, most probably, close to the activation energy of ablation product from the excited state. This is a specific feature of "cold" ablation of strongly absorbing matter. The flame expansion is described within the framework of isoentropic hydrodynamics and the absorption of incident radiation in the flame (the screening effect) is taken into account as first-order perturbation.

2) In the case of a weakly absorbing matter, the flame formation corresponds to the bulk evaporation process and the ablation boundary is determined by the value of density ρ^* starting from which the flame is considered to be transparent for the incident radiation. Within the region of fluences where the temperature of the ablation surface becomes comparable with the critical temperature the dependence of ablation depth on fluence is close to $d \propto F^{1/3}$.

3) For pulse durations $\tau \sim 10^2$ ns where the size of the flame becomes comparable with the focal spot radius, and for large laser fluences where the ablation surface temperature exceeds the critical one, the absorption of radiation in the flame exerts the decisive influence on the ablation development.

ThZ30

ACOUSTIC WAVES IN METALS EXCITED BY ULTRASHORT LASER PULSES

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Interaction of femtosecond laser pulses with metals has become a subject of strong interest due to both new physics involved and demonstrated applications. At present, investigations in this field are stimulated by the discovered ability of ultrashort pulse lasers to fabricate microstructures on metal targets. Theoretical studies of femtosecond heating of metals are usually based on the solution of differential equations for the electron and lattice temperatures with the boundary conditions determined by laser absorption in a skin-layer. Heat transport and electron-lattice energy exchange are described in a traditional way by electron-electron and electron-phonon collisions. At the same time, there are some experimental results which require more sophisticated analysis of the relaxation processes. In particular, it is of great importance to study the generation of intense acoustic oscillations and their influence on the electron heat transport. The present report is devoted to the theory of this phenomenon.

During the femtosecond pulse laser-metal interaction the parametric amplification of ion-acoustic waves arises due to the rapid electron heating. The corresponding growth of the electron Debye radius is responsible for a strongly non-equilibrium spectrum of ion-acoustic oscillations. A quasi-stationary distribution of the ion-acoustic wave numbers is found which is localized at wave numbers of the order of the inverse electron Debye radius. The formation of non-equilibrium distribution of ion-acoustic oscillations is followed by an anomalous increase of the effective electron collision frequency and results in a stabilization of the electron heat flux.

ThZ31

FILAMENTATION OF ELECTROMAGNETIC RADIATION IN WEAKLY COLLISIONAL PLASMAS

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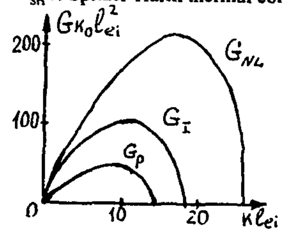
Filamentation of laser radiation attracts the interest of specialists for a long time [1]. If the filament wavelength 1/k is comparable or smaller than the electron mean free path l_{ei}, the description of filamentation is possible in the frames of the nonlocal transport theory [2]. When the laser field is strong enough, the electron thermal conductivity depends also on the radiation intensity that results in the additional dependence of filamentation on the field intensity. In the present paper the new peculiarities of filamentation caused by the influence of the field on the nonlocal thermal conductivity are reported. The new nonlinear effects take place at unusually low field intensities when the electron velocity of oscillations in the field v_E is much smaller than $v_T/\sqrt{Z}$, where v_T - electron thermal velocity, Z – ion charge number. The discussed effect can be understood on the basis of the new interpolation expression for the effective thermal conductivity : $\kappa(k)=\kappa_{SH}\left\{1+12(Zk^2l_{ei}^2)^{5/7}\left[1+0.04(Zv_E^2/v_T^2)^{6/5}(Zk^2l_{ei}^2)^{18/35}\right]^{-1}\right\}^{-1}$, where κ_{SH} is Spitzer-Harm thermal conductivity. The filamentation growth rate G_I obtained in



the frames of our theory is shown in the Figure. Here $k_0=2\pi/\lambda_0$, $\lambda_0=1\,\mu m$, T = 5 keV, Z = 40, $n/n_c=0.1$, n_c- critical density, $I=2\cdot10^{14}$ W/cm^2, G_P and G_{NL}- ponderomotive and nonlocal field-independent growth rates, respectively. Figure shows that the influence of relatively weak field on electron thermal conductivity leads to the increase of the wavelength of the most effectively growing filament and to the decrease of the growth rate, compared to the results of the field-independent nonlocal theory [2].

[1] Kruer W.L., Comm. Plasma Phys. Contr. Fusion, 9, 63 (1985).

[2] Maximov A.V., Silin V.P., JETP, 76, 39 (1993).

ThZ32

HEAT WAVE IN A METAL TARGET IRRADIATED BY ULTRASHORT LASER PULSE

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The problem of heat flux penetration into the metal target irradiated by high power femtosecond laser pulse is considered analytically and numerically. The modelling of a heat wave is based here on the kinetic equation solution for electron distribution function with taking into account the electron-electron and electron-phonon collisions. This approach allows us to include accurately in the theory the effects of finite velocity of heat transfer, of large difference between electron and lattice temperatures, and transport coefficient dependence on the local electron temperature. The results of the modelling are compared with the results of parabolic (diffusional) two-temperature approximation [S.I. Anisimov, et al., Sov. Phys. JETP, 39, 375 (1975); P. Corcum, et al., Phys. Rev. Lett., 61, 2886 (1988)], and of hyperbolic heat conduction model, as well as with the experimental data on femtosecond electronic heat-transport dynamics in thin films [S.D. Borson, et al., Phys. Rev. Lett., 59, 1962 (1987)].

The analysis of space-temporal dynamics of heat wave allows us to find optimum parameters of laser pulse - metal interaction to obtain maximum efficiency of the process of ablation.

ThZ33

Ultra-short laser pulse interaction with transparent dielectrics and metals

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Material ablation with ultrashort laser pulses (USLP) is a promising technology. With USLP, very precise material removal can be accomplished with minimal collateral damage to surrounding material for both metals and dielectrics. At high laser intensity multiphoton ionization and subsequent electron avalanche processes produce sufficient electron density for effective light absorption in transparent materials. We calculated the ablation threshold and spatial distribution of absorbed energy together with the subsequent plasma expansion and shock propagation in the material. Cumulative thermal heating from multiple pulses has been analyzed to determine the maximum tolerable pulse repetition rate. We will describe crater formation.

ThZ34 Ablation and modifications of dielectrics by ultra short laser pulses

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In the present communication we theoretically elucidate the effect of ultra short laser pulses (USLP) of moderate intensity on dielectrics in which the primary absorption at the wavelength of the USLP corresponds to electronic transition to localized state. Our consideration applies to the majority of polymers and to relatively wide gap dielectrics doped by dyes. We study USLP material heating for various models of electronic structure of chromophores such as two-, three- and four- level systems with different relations between relaxation times and absorption cross-sections for corresponding transitions.

We concentrate on two kinds of experiments. First, we describe the effect of two successive ultraviolet (UV) USLP on linearly highly absorbing dielectrics and investigate the dependence of the ablated depth on the delay time between USLP within the framework of a surface evaporation model of laser ablation. The conditions are derived when the ionization in the case of UV USLP ablation of highly absorbing polymers is insufficient. We construct the models, which take into account the stepwise ionization while the impact ionization is neglected. We demonstrate that our modeling permits to understand the main features of experimental data on pair pulse ablation of polyimide by UV USLP published in [1]. The possible role of mechanical stresses resulted from the USLP material heating in such kind of experiments is estimated.

Second, we consider from the point of view of our models recent experimental data [2] on 3D bitwise optical information recording that was performed using a Ti:Sa laser in PMMA doped with spiropyran molecules. We follow different kinds of material modification dependent on the extent of beam focusing into the bulk of material. The possible role of stepwise, and impact ionization in this case is discussed.

1. S.Preuss, M.Spaeth, Y.Zhang, M.Stuke, *Appl.Phys. Lett.*, v.62, p.3049, (1993).

2. A.I.Korytin, N.M.Bityurin, A.P.Alexandrov, N.A.Babina, L.A.Smirnova, and A.M.Sergeev, *Optical Memory & Neural Networks.*, 1998, (in print)

ThZ35 Formation of Periodic Structures under nanosecond and subpicosecond UV-Laser Ablation of stretched Polymer Films

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The theory of non-coherent periodic (micrometer scale) structures formation in stretched polymers under UV-laser ablation is developed. The externally applied (or frozen in) tensile stress is shown to be a prerequisite for structure formation in initially isotropic media. The geometries, periods, and times of formation of structures are calculated as a function of laser-light intensity, laser-induced temperature, and external stress. The theoretical results are in good agreement with experimental data obtained with nanosecond [1] and subpicosecond [2] laser pulses.

UV-laser light excites electrons from the ground state to excited vibronic states of chromophores. Since nonradiative relaxations of electronic excitations result in the generation of broken bonds which alter the elastic properties of the medium, we consider the layer with thickness of the optical penetration depth h as a "film" bonded to the underlying "substrate". In nanosecond time domain the Thermal-Deformational(TD) instability can develop in this film in the following way. The non-radiative electronic relaxation is accompanied by the generation of thermal phonons. The rate of heat release is spatially modulated along the surface by an initial fluctuation Fourier component of the surface strain coupled with surface corrugation. This process creates a periodic temperature field, and thus periodic thermoelastic forces that enhance the initial fluctuation corrugation. Due to this positive feedback between strain and temperature, the initial state of uniform heat generation within the film h becomes unstable at some critical temperature and transition to a state with spatially periodic temperature distribution and periodic surface corrugation occurs. The process takes place during the pulses on an overall time scale of 10^{-7}s, and it may explain the observation made in the nanosecond multiple-pulse regime. With subpicosecond laser excitation defect selforganization occurs due to an Electronic-Deformational(ED) instability which develops in the following way: A fluctuation Fourier component of the strain modulates electronic excitations flux and thereby leads to the lateral modulation of the (number) density of electronic excitations within the layer h. This process is accompanied by arise of elastic forces that, in turn, enhance the initial fluctuation in the deformation. This positive feedback occurs at a certain critical laser intensity. In subpicosecond multiple-pulse regime this process takes place between the pulses on a overall time scale of 10^{-8}s. The symmetry of the externally applied tensile stress controls the symmetry of the resultant TD and ED-structures, the formation of which is accompanied by a periodic modulation of the production of broken bonds which causes periodic ablation. The symmetry and period of the observed ablation structure thereby follows the characteristics of the TD and ED-structures.

References: [1] E.Arenholz, V. Svorcik, T.Kefer, J.Heitz, and D.Bäuerle: Appl.Phys. A 53, 330 (1991). [2] J.Heitz, E.Arenholz, D.Bäuerle, R. Sauerbrey, H.M.Phillips: Appl.Phys. A 59, 289 (1994)

ThZ36

GASDYNAMIC PERTURBATIONS IN LASER-INDUCED VAPORIZATION PROCESSES

V.I .Mazhukin[1], A.A.Samokhin[2], C.Boulmer-Leborgne[3]
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Effect of gasdynamic perturbations on laser-induced vaporization processes is investigated at different values of Mach number $M \leq 1$ in the vapor flow. Vaporization kinetics at liquid-vapor interface is described by gasdynamic boundary conditions for mass, momentum and energy fluxes across the plane transition front. The fluxes depend on the surface temperature T_S and M in the vapor flow just above the Knudsen layer. In stationary vaporization processes T_S and M can be considered as independent parameters.

It is not the case for time-dependent vaporization processes, where $T_S(t)$ and $M(t)$ are not independent, their behavior being determined by coupled hydro- and gas-dynamic problems for liquid and vapor phases respectively.

Modulation $\delta T_S(t)$ of the surface temperature perturbs the Mach number and the resulting modulation $\delta M(t)$ gives rise to the additional perturbation of the vaporization kinetics in accordance with the interface boundary conditions. In the case of small harmonic modulations $\delta T_S(t)$ and $\delta M(t)$ have the same signature.

It is shown that the gasdynamic perturbations in subsonic $M<1$ vapor flow enhance the quasiresonant response of the laser-induced vaporization processes to the laser intensity modulation [1] as compared with the case $M=1$ considered earlier [2].

The perturbations affect also ripples behavior at the evaporating liquid surface considered previously [3] for the case $M=1$. Effect of the perturbations diminishes as M approaches unity from below provided mass and energy fluxes across the phase transition boundary have extreme at $M=1$.

References.

1. V.I.Mazhukin, A.A.Samokhin, C.Boulmer-Leborgne. Phys.Lett. A 231 (197), 93.
2. A.A.Samokhin, A.P.Guskov, Phys.Lett. A 77 (1980) 344.
3. A.A.Samokhin. Proc. of IOPAN, USSR AS #13, Nova Science Publ., N-Y, 1990

F R I D A Y

3 July 1998

SESSIONS:

FA - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies III
FB - Biomedical Optics I
FC - Interference Phenomena in Atomic Systems III
FD - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics VII
FE - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies IV
FF - Biomedical Optics II
FG - Interference Phenomena in Atomic Systems IV
FH - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics VIII

SESSIONS:

FRIDAY

8:30-10:45 **GREEN HALL**

FA - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies III

Presider: *A.L. Mikaelian, Inst of Optico-Neural Technologies, Russia*

8:30
FA1
(Invited)

Optical Pattern Formation: From Curiosity To Application

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SUMMARY

Nonlinear optical spatio-temporal dynamics including optical patterns and localized state formation, spatio-temporal oscillations, chaotic regimes is one of the fastest growing fields in modern optics. These studies resulted not only in a large variety of aesthetically attractive patterns and waves as recently seen in nonlinear wide aperture (two-dimensional) optical systems, but also in new opportunities for image/signal processing and adaptive optics. In general, the more complex the nonlinear system dynamics the greater the potential information processing capability of that system. The key questions are: how to use this potential, and how to design and control complexity having the properties we desire.

New results are presented for an optical system with a controllable phase-only spatial Fourier filter placed in the system's diffractive feedback loop. By controlling the feedback field spectral component phase in a nonlinear system with an LCLV and diffractive feedback we were able to realize controlled transitions between spatio-temporal regimes as observed in both experiments and numerics. Patterns originating from interactions between spatial modes belonging to different instability bands (black-eye patterns, decagons, etc.) were analyzed, as well as localized states and traveling shock waves. Nonlinear dynamics of 2D optical systems can be efficiently used for nonlinear image processing and high-resolution adaptive optics. We consider a new type of 2D feedback system with artificially (opto-electronically) created nonlinearities. Using high-resolution liquid-crystal phase modulators combined with a fast camera, analog VLSI chip (or digital image processing system) one can design a nonlinear response (intensity-phase modulation transformation law) having properties desirable for information processing.

9:00
FA2
(Invited)

A Holographic Video System Based on Pulsed Laser Illumination and Its Perspective

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A pulse laser holographic video was recently built[1,2] to eliminate scanner type mirrors used it the previous system[3]. The holographic video system is basically consisted of 4 functional blocks such as a laser source for illumination, (an) AOM(s) for holographic fringe data display, demagnification optics and a diffuser plate for reconstructed image display with reasonable viewing angle, and a computer for holographic fringe data preparation to realize electro-optical means of displaying holograms. In the CW laser version of the system, it is essential to use a polygon mirror or a scanner array to compensate moving of the reconstructed image due to the fringe data flow in the AOM and to increase the aperture size of the AOM effectively. When a pulse laser is used instead of the CW, the polygon mirror or the scanner array is not necessary because the moving is almost stopped by a very short laser beam. However, a mean for increasing f the AOM aperture size effectively. This is done by a multichannel AOM consisted of g many trapezoidal shape AO cells joined in a line with very small gap between them, a helical stack of thin slit type mirrors and an AO deflector for controlling beam incident direction to the multichannel AOM. The AO deflector directs the diffracted beams from the AOM to each corresponding mirror of the slit type mirrors. The beams reflected from the mirrors are joined together to make a single hologram line. The current pulse laser system has a multichannel AOM consisted of 6 AO cells and the slit type mirrors stacked with 6 mirrors. This combination produces the effect of 36 parallel AO cells joined together to make a single hologram line.

The pulse laser system can be improved to display a bigger hologram size by adding more AO cells to the multichannel AOM and employing a viewing zone multiplexing technique[4]. The technique allows to increase the viewing angle without demagnifying the reconstructed image size. The further improvement of the system will be done by employing high speed AO cells and driving electronics. It is difficult to say that the current holographic video techniques can lead the future 3 dimensional imaging media based on the holography, however, it will provide guidance for the development of future holographic 3 dimensional TV.

[1] Sergey A. Shestak, Jung-Young Son, Seong-Keun Lee, and Hyung-Wook Jeon, SPIE Proc. vol. 2652, pp.24-28 (1995).
[2] Jung-Young Son, Sergey A. Shestak, Yong-Jin Choi, Sung-Kyu Kim, Shin-Hwan Kim and You-Seek Chun, Proc. of SPIE International Conference-Colloquium on Optical Holography and its Applications, Kiev, Ukraine (June 24-25, 1997).
[3] P. St.-Hilaire, S. A. Benton, and M. L. Jepsen, J. Kollin, H. Yoshikawa, SPIE Proc. vol. 1212, pp.174-182 (1990).
[4] S. A. Shestak and Jung-Young. Son, SPIE Proc. vol. 3293, p.3293-02 (1998).

9:30
FA3
(Invited)

ALL-OPTICAL PROCESSING OF DIGITAL DATA USING THE TECHNIQUE OF OPTICAL SOLITARY WAVES

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Results of many reseaches, which have been carried out within the last years to create the digital optical processors with a picosecond bit rate, show that extremal performance data of such processors are difficult to achieve under acceptable level of the optical energy consumption when conventional methods are used. In connection with this, it holds the great interest to develop a novel avenue to attacking some problems in a high-bit-rate optical information processing. An approach under proposal combines, on the one hand, the potentialities of both fiber and semiconductor technologies and, on the other hand, the advantages inherent in the technique of optical solitary waves. A special feature of the approach under cosideration is a hybrid arrangement of optical processors, which provides functional matching the semiconductor laser structure to the single-mode fiber, complementing each other to shape and support the regime of optical solitary waves. A hybrid arrangement of digital optical processors exhibits unique performances, in particular, in the operation broadband (up to 10 THz) as well as in the optical energy consumption (down to 1 pJ/bit) and implements in full measure all the possibilities of the technique of optical solitary waves in a high-bit-rate data processing. As examples of an advanced arrangement the following hybrid processors are considered in the report:
- semiconductor test-generator of multibit words, including picosecond optical pulses;
- two versions of lengthy spans for fiber transmission systems using solitary wave regime of lumped recovery in multilayer semiconductor structures for symbol pulses, which are in themselves fundamental or guiding-center solitons, as the case requires, in a fiber link;
- an all-optical device for data storage with random access to the memory based on the circulation of guiding-center solitons through a long-haul external fiber cavity joined a mode-locked single-mode semiconductor laser.

10:00
FA4
(Invited)

Long-term storage of a beat stream of pulses in a fiber loop by stimulated Raman scattering

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One of the promising elements for all-optical system is the all-optical circulating fiber loop memory [1]. The principle of its operation is a running sequence of pulses around a closed fiber loop. In order to use the loop as a long-term memory, three conditions have to be met for a long time: (a) the pulses corresponding to logic ones must remain recognizable as ones, (b) the pulses corresponding to logic zeros must also remain recognizable as zeros, and (c) they must not walk off their assigned position. To provide these conditions, we need to use some nonlinear elements for optical pulses regeneration.

In this report we discuss a method, based on the use of a logic gate operating through stimulated Raman scattering. The scheme of the gate consists of connected in series a fiber SRS amplifier, spectral filter that transmits the pump pulses and rejects Stokes pulses, and a fiber SRS generator. The parameters of the Raman amplifier, generator, and pump pulses are chosen in such a way that the pump pulse introduced into the amplifier do not produce high-power Stokes pulses on its output, however the same pulse introduced into the generator results in high-power one.

For operation, two sequences must be introduced to the gate. One is pump pulse sequence with the constant pulse power, and another one is a binary signal pulse sequence with Stokes wavelength. Numerical simulation has shown that such gate provides very abrupt dependence of the output power on the input one for the Stokes pulses and can be used as regenerator for them. The effects of self-phase modulation and pulse dispersion have been taken into account. The case of negative and positive group velocity dispersion has been examined. The possibility to operate with pulses as short as 1 ps have been shown.

Experimentally, the operation of the loop memory with SRS gate output closed by the 820-m fiber with the same gate input have been investigated. A Nd-YAG mode-locked laser with a wavelength 1064 nm, pulse repetition frequency of 100 MHz, and pulse duration of 100 ps was used as a pump. The circulation of the Stokes pulse sequence during 10 min, which corresponds to the 10^6 round trips, was observed.

1. E.A. Kuzin, J.J. Sanchez Mondragon, V.I. Belotitski, V.A. Vysloukh, and A. Menses //. JOSA B, 14, No. 6, P. 1345 (1997).

10:30
FA5

Shift Holograms for Data Storage

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3-D holograms multiplexing is acknowledged to be among the most efficient ways of the dense data storage. Below we consider holograms multiplexed by means of a shift of a light-sensitive material in respect to the speckle reference wave [1]. The holograms multiplexing is performed by shifting of the material by the distance equal to the mean size of a speckle. The recorded holograms are reconstructed with the same speckle-reference wave, the hologram being shifted by the same distances as at the stage of the recording. An experiment on the recording and reconstruction of the speckle-shift hologram in a $LiNbO_3$ crystal and dichromated gelatin [2,3] has confirmed that the shift of the hologram by the distance equal to the mean size of the speckle gives rise to a new image of the recorded page of information. The theoretical estimation has shown that the multiplexed speckle-shift hologram presents much more independent cells for the data storage than an angular multiplexed hologram. At the same time, it is shown that if the noises are taken into account, the attainable density of the information storage is equal to that which takes place in the case of the wavelength multiplexed hologram. A so-called one-dimensional axial hologram has been suggested. This hologram presents a pattern that looks like a thin long thread that is perpendicular to the surface of the layer of the light-sensitive material. The experiment on recording one-dimensional holograms has been carried out when using thick-layered dichromated gelatin.

References

1. V.B.Markov and A.M.Darskii. Optika i Spektroskopija, v.65, pp.661-665, 1988.

2. Yu.N.Denisyuk, N.M.Ganzherli, I.A.Maurer, and S.A.Pisarevskaya. In: T.J.Trout ed. SPIE Proc., vol.3011 "Holographic Materials III", 1997, pp.244-247.

8:30-10:45 **RED HALL**
FB - Biomedical Optics I
Presider: *A. Nitzan, Tel Aviv Univ., Israel*

8:30
FB1
(Keynote)

Optical Coherence Tomography for Medical Imaging and Diagnosis

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Summary

Optical coherence tomography (OCT) is a recently developed optical imaging technique that performs high resolution, cross-sectional imaging tomographic of microstructure in biological systems. OCT is analogous to ultrasound B mode imaging except that it uses light instead of sound. OCT performs imaging by using low coherence interferometry to measure the optical backscattering of tissue as a function of echo delay and transverse position. The resulting two dimensional data set can be displayed as a gray scale or false color image. OCT functions as a type of "optical biopsy" to provide cross sectional images of tissue structure on the micron scale. OCT is a powerful imaging technology because, unlike conventional histopathology which requires removal of a tissue specimen and processing for microscopic examination, OCT can provide images of tissue in situ and in real time, without the need for excision.

OCT has originally been developed and applied by our group for tomographic diagnostics in ophthalmology. OCT can provide images of the retina with resolutions of 10 μm, one order of magnitude higher than conventional ultrasound. Working in collaboration with the New England Eye Center and MIT Lincoln Laboratory, we have developed a clinical prototype OCT instrument and examined over 5000 patients. The technology has been transferred to industry and a commercial product was introduced into the ophthalmic market last year. Studies in ophthalmology show that OCT is especially promising for the diagnosis and monitoring of diseases such as glaucoma or macular edema associated with diabetic retinopathy where it provides quantitative information on disease progression. In many cases OCT has the ability to detect and diagnose early stages of disease before physical symptoms and loss of vision occurs.

Recent basic research on OCT has focused on extending this technology to perform optical biopsy in internal medicine. OCT at optical wavelengths in the near infrared at 1.3 μm where tissue scattering is minimized allows imaging to be performed to depths of 2-3 mm. Using solid state modelocked laser sources which can provide both short coherence lengths and high powers, high resolution and high speed imaging may be achieved. Image resolutions of <5 μm and high speed acquisition of 250 x 250 pixel images at rates of 8 frames per second has been achieved. OCT imaging has been integrated with microscopy to perform imaging of specimens *in vitro*. A prototype single mode fiber optic catheter/endoscope with a diameter of 1 mm has been developed which can transluminally image internal tissue structures such as the respiratory tract, gastrointestinal tract, or arteries. In recent studies, we have demonstrated catheter/endoscope based OCT imaging of internal organs in an animal model. Forward imaging devices such as a laparoscope and hand held surgical probe have also been developed and demonstrated.

This presentation will review recent advances in OCT technology as well as possible future clinical applications such as arterial imaging, the detection of early neoplastic changes, and guiding surgical intervention.

9:15
FB2
(Invited)

RECENT RESULTS AND APPLICATIONS OF OPTICAL COHERENCE TOMOGRAPHY

F.I.Feldchtein, V.M.Gelikonov, G.V.Gelikonov, N.D.Gladkova, N.M.Shakhova, L.S.Dolin, and A.M.Sergeev
Institute of Applied Physics, 46 Uljanov st, 603600 Nizhny Novgorod, Russia

The optical coherence tomograpy (OCT) in the near infrared frequency band is a rapidly progressing technique for noninvasive, high spatial resolution imaging of superficial biotissues. Our approach in OCT is based on using polarization maintaining (PM) optical fiber interferometry with low-coherence radiation sources to produce fast acquisition rate, high dynamic range, 2d and 3d imaging in scattering media.

The characteristics of our OCT devices that are now routinely used in clinical experiments are as follows. The power of low-coherence infrared sources is 1-2 mW with the central wavelength of 0.83 micron or 1.28 micron and the bandwidth of 30-50 nm. The in-depth scanning rate produced with an integrated piezo-optical modulator is 30 cm/s, which provides the acquisition of an OCT image of a 200x200 pixel size with the spatial resolution of 15 micron for approximately 1 s. The "single-frame" dynamic range of our OCT scheme, determined as the incident power divided by the minimal backscattered signal, is 90 dB.

The developed technology is compatible with existing medical diagnostics including endoscopy and laparoscopy. It provides the direct application of OCT devices in clinical studies to get unique in vivo information on human tissues. In this report, we present data obtained and systematized after studying dozens of patients, both normal and with pathologies of internal organs.

First of all, we will address the capability of OCT to obtain in vivo information on alterations of microstructure in the depth of human mucosa in gastrointestinal, respiratory, urinary and genital tracts. The most interesting point here is examination of the state of the basal membrane. Thus, the local disappearance of the basal membrane, that can often be monitored by OCT, is known as a criteria of invasive cancer. This knowledge helps in carrying out OCT-guided excisional biopsy thus increasing the probability of taking a proper biopsy material from exactly localized suspicious areas.

Another important conclusion we have derived from our observations is that on the correlation between OCT images and functional states of the human body in general. It opens a completely new direction in OCT applications. As an example, the thickness of mucous membranes in the female genital tract is known to depend on the estrogen concentration. Based on this knowledge and measuring the size of the epithelial layer in OCT images of uterine cervix we have a additional method for evaluation of ovarian hormonal activity.

The next promising application of OCT is for guiding the treatment and assessing the adequacy of treatment of mucosa pathologies. As an example, we present our results on monitoring therapy of uterine cervix, namely an operation of cryodestruction. We demonstrate that the pre-operative information given by OCT on the depth and border of a precancer lesion is important to minimize the zone of damage and to define the doze of the treatment.

Finally, we report our very recent application of OCT in laparoscopy. By introducing a flexible probe arm of the OCT interferometer through a trocar we have got a unique opportunity to examine the mucosa structure of internal organs in abdominal cavity. In particular, we have recorded in vivo images of human ovary and a pathological state in the form of ovarian fibroma.

9:45
FB3
(Invited)

LASERS-BASED HIGH RESOLUTION OPTICAL BIOIMAGING

Daniel L. Farkas
Center for Light Microscope Imaging and Biotechnology
Carnegie Mellon University, Pittsburgh PA (USA)

Optical imaging is unique in its capacity for non-invasive analysis of cells and tissues. Microscopy has long been the dominant technique, and has enjoyed a veritable renaissance, as recent progress allows study of living cells, both dynamically and in three dimensions. Developments in several fields made this possible, none more important than physics. Laser light sources have been particularly useful in yielding significant improvements in the spatial, spectral and temporal resolution of light microscopy.

Progress in this field will be reviewed, emphasizing technological advances [1] and our recent contributions. We developed robotic, machine vision-type microscopy allowing live monitoring of events at the subcellular level [2], and further enhanced it spectrally and temporally by improving the performance of acousto-optic tunable filters [3]. Microscopic imaging with overall resolution an order of magnitude better than current standards is presented, together with some selected applications, including spectral imaging [4], and extensions to the tissue level [5]. Our results in optical coherence tomography [6] imaging of skin are compared with those obtainable by other laser-based bioimaging such as confocal scanning and multiphoton excitation microscopy.

The future of optical functional imaging as a means of monitoring metabolic activity in vivo is discussed, in the context of potential contributions to important medical fields such as transplantation and cancer research.

1. Farkas, D.L., et al. (editors) (1998) Optical Investigations of Cells In Vitro and In Vivo. Progress in Biomedical Optics (Proc. SPIE), vol. 3260.
2. D.L. Taylor et al. (1997) Ann. New York Acad. Sci., 820, 208-228.
3. Wachman, E., Shonat, R. et al. (1997) Biophysical Journal, 73, 1215-1231.
4. Farkas, D. L., et al. (1997) Springer Lecture Notes in Comput. Sci., 1311, 663-671.
5. Ballou, B. et al. (1997) Biotechnology Progress, 13, 649-658.
6. Pan, Y. and Farkas, D.L. (1998) Journal of Biomedical Optics, in press.

10:25
FB4

SIMULTANEOUS OPTICAL COHERENCE TOMOGRAPHY AND CONFOCAL IMAGING FOR RETINAL INVESTIGATIONS

Adrian Gh. Podoleanu and David A. Jackson

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For the investigation of the eye fundus, two modern techniques are used by the visual scientists and ophthalmologists: scanning laser ophthalmoscopy (SLO) and optical coherence tomography (OCT). The images oferred by the two systems are complementary and admit different interpretations. The goal of this paper is to discuss possible implementations where a confocal image as that presented by SLO and an en-face image with a depth resolution much better than the SLO images, obtained by OCT are produced simultaneously. The utilization of two instruments in parallel, OCT and SLO, is excluded due to losses and optical disturbances introduced by the transfer optics elements shared by the two instruments. The noise associated with the low coherence sources used for the OCT and the fiber end reflections preclude the utilization of the intrinsic confocal profile of the fiberised OCT object arm. Consequently a separate bulk optical confocal receiver is introduced between the transversal galvanometer scanner and the OCT fiber arm. Experiments using this hybrid system are presented which show the usefulness of a simultaneous confocal image while presenting a transversal OCT image. Owing to the low coherence length of the source, the OCT transversal images show only fragments of the retina and are difficult to interpret on their own. Both SLO and OCT images are obtained at the same rate and they are in strict pixel to pixel correspondence. We have found it useful to superimpose the OCT and SLO images, to provide a combined OCT/SLO image. The weights of the two signals in the final image is a matter of choice and determined by the specific target.

8:30-10:45 **BEIGE HALL**

FC - Interference Phenomena in Atomic Systems III

Presider: *Ya.I. Khanin, Inst. of Applied Physics, Russia*

8:30
FC1
(Invited)

Paper is not available

9:00
FC2
(Invited)

Recent Developments in Local Field Effects in Nonlinear and Quantum Optics

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Effects of Lorentz-Lorenz local fields are manifest in matter-laser field interactions where the density of the medium is such that there are, on the average, many atoms or molecules within some cubic resonance wavelength. The local field-atom interaction is reviewed from the microscopic, semi-classical approach. Some important and novel results of the formulation and predictions for corresponding experimental observations are reviewed. These include recently experimentally observed intrinsic optical bistability, the spectral red shift in the ground state of a two-level system, and the more recently observed excitation dependent spectral shifts and line narrowing. Each of these phenomena are discussed in relation to theoretical prediction and experimental observation. The results of these experiments and their close agreement with theoretical predictions provide impetus for further experimental investigations of important novel predicted, but as yet unobserved effects of local fields. These include, a) enhancement of refractive index and gain in lasing without inversion [1] (LWI); b) nonlinear effects in electromagnetic field induced transparency (EIT); c) piezophotonic and magnetophotonic switching [2]; d) intrinsic adiabatic inversion [3]; e) intrinsic strong self phase modulation in self induced transparency [4] (SIT). These novel predicted phenomena are discussed in connection with aspects of approach to experimental observations.

1 J. P. Dowling and C. M. Bowden, Phys. Rev. Lett. {bf 70}, 1421 (1993).
2 A. S. Manka, J. P. Dowling, C. M. Bowden and M. Fleischhauer, Phys. Rev. Lett. {bf 73}, 1789 (1994).
3 M. E. Crenshaw and C. M. Bowden, Phys. Rev. Lett. {bf 69}, 3475 (1992).
4 C. M. Bowden, A. Postan, and R. Inguva, J. Opt. Soc. Am. {bf B 8}, 1081 (1991).

9:30
FC3
(Invited)

NEW TYPES OF COOPERATIVE LIGHT-MATTER EXCITATIONS IN MULTICOMPONENT AND MULTILEVEL MEDIA

A.V.Andreev
Physics Department, M.V.Lomonosov Moscow State University,
Moscow 119899 Russia

Solitons in the excited two-level medium of finite length. The solutions of the Maxwell-Bloch equations have been found for the case of two-level extended medium of finite length. In contrast to the solitons of the infinite medium in this case the solutions have the non-local form, as a result the soliton shape is transformed when pulse passes through the medium boundary. Another specific feature is that if the atomic system is initially in the ground state then the medium excitation propagates along with the optical pulse. In the initially excited medium the optical pulse inside the medium and the medium excitation propagate in the direction opposite to the incident pulse.

Pulse propagation in two-component media. The two-component media consists of the mixture of the two-level atoms with the different dipole matrix elements of the resonant transitions. The soliton solutions have been found for the different initial states of the components. The specific type of the collective light-matter excitations appropriate to the two-component media are the pulses of stationary area. If the slow component is excited initially and the fast component is in the ground state the incident pulse can be amplified without changing its area. The pulse amplitude increases and its temporal width decreases with the travelled distance. The efficiency of amplification depends on the component concentration and can be significantly higher than that in the monocomponent medium of the excited atoms alone. The pair of the incident pulses can propagate in the two-component medium as an unified excitation. In dependent on the initial distance between the pulses they can propagate as an oscillating, colliding or solitary pulse pair.

Solitons of three-level media. It has been shown that the possibility of exciting of the self-similar pulses in the adjacent transitions is determined by the square root of oscillator forces ratio (α). At the exact resonance the simultons of the Λ- scheme occur in the case when α is an integer. In this case the pulse in strong transition has a few maxima, the number of which is equal to α. The Raman solitons exist at any arbitrary value of α. The number of deeps in the dark soliton is determined by the whole part of α. For the Λ- scheme the off-resonant simultons and Raman solitons are phase-modulated.

10:00
FC4
(Invited)

Quantum Interference Effects in Atomic Systems Under Multiphoton Resonances

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Quantum interference between different optical transitions in various atomic systems is reviewed. Suppression of multiphoton ionization, multiphoton absorption, and coherent control is considered. As a example, two-photon excitation of a nonlinear medium used in two-photon resonantly enhanced third-harmonic generation is considered in detail. By changing the relative phases between the laser field inducing these optical transitions one can vary the quantum nonlinear interference from destructive to constructive. Connection of reviewed phenomena with other coherent effects as to changing absorption spectrum, amplified spontaneous emission and laser without inversion is discussed. Suppression of absorption and effect of medium transparency is analyzed. The coherent effect of making a medium transparent for one-photon and three photon transitions of band-to-band excitation in semiconductors is predicted.

Also quantum mechanical interference by using to excitation paths to populate a discrete and continuum states and varying the frequency deturnings and relative phase is demonstrated. Strong isotope effects for the ionization and dissociation some kind atoms and molecules are found.

10:30
FC5

LIGHT SHIFT OF COHERENT POPULATION TRAPPING RESONANCES

R. Wynands, A. Nagel, D. Meschede
Institute for Applied Physics, Bonn University, Wegelerstraße 8, 53115 Bonn, Germany
B. A. Grishanin, V. N. Zadkov
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A cesium cell illuminated by two laser light beams resonant with the D_2 transition becomes transparent when the laser difference frequency corresponds to the 9.2 GHz hyperfine splitting: the coherent population trapping resonance. When the two lasers have different intensities the minimum of the absorption shifts with intensity. Using an optical phase-locked loop to control the laser difference frequency we can obtain linewidths of 10 kHz for simple vapor cells and less than 50 Hz for cells with neon as a buffer gas [1], allowing a precise determination of the resonance shift. Fig. 1 shows the shift of the resonance position vs. laser intensity for two different experimental conditions (squares and circles).

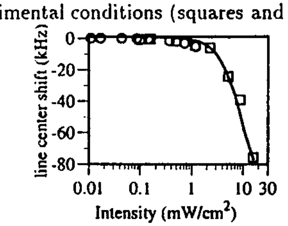

Fig. 1: Shift of the dark resonance

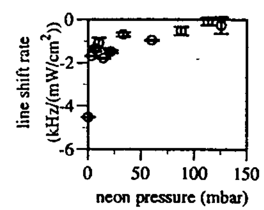

Fig. 2: Decrease of shift rate

A theoretical model calculation for the shift starts with the absorption coefficient for a three-level Λ system, augmented by the effects of a second excited level ($F = 3$ and $F = 4$ in the $6P_{3/2}$ state) and integrated over the thermal velocity distribution of the atoms. First results are shown as a solid line in fig. 1.

In a buffer gas the homogeneous linewidth of the optical transition increases, leading to a reduction of the shift. When for simplicity a straight line is fitted to the shifted positions vs. intensity one finds a strong decrease of slope with increasing pressure (fig. 2).

[1] S. Brandt, A. Nagel, R. Wynands, D. Meschede, Phys. Rev. A 56, R1063 (1997).

8:30-10:45 **BLUE HALL**

FD - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics VII

Presider: *A.M. Sergeev, Inst. of Applied Physics, Russia*

8:30
FD1
(Invited)

Ultrafast Chirped Pulse Amplification and Applications

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Chirped pulse amplification of 10-fs seed pulses has lead to the generation of multiterawatt optical pulses at unprecedented repetition rates; three to four orders of magnitude higher than similar peak power, large-scale Nd:glass or gas laser systems. These ultrafast systems now allow investigations of ultrahigh field laser/matter interactions and applications to be performed in university-scale laboratories, bringing the physics of the extreme to the table-top. Amplification at such short pulse durations presents many challenges not present in picosecond timescale systems. A review of methods for control of higher order phase distortion, gain narrowing and accurate characterization of sub-20-fs, multiterawatt pulses will be presented. Because of the high repetition rate of ultrafast CPA systems, from a few Hz to kHz, many new high field applications have become practical. As one example, a review of our efforts to study femtosecond and picosecond dynamics of solid state and chemical interactions with ultrafast-laser-produced x-rays via time-resolved x-ray diffraction and x-ray absorption spectroscopy will be presented.

9:00
FD2

INTERACTION OF SUPERINTENSE FEMTOSECOND LASER RADIATION WITH NANOSTRUCTURED TARGETS

V.M.Gordienko, M.S.Dzhidzhoev, A.B.Savel'ev, and R.V.Volkov
International Laser Centre & Physics Faculty, M.V.Lomonosov Moscow State University, Vorobyevy gory, Moscow, 119899, Russia; e-mail:gord@femto3.ilc.msu.su

The interaction of femtosecond laser pulses with solid targets provides ultra bright source of subpicosecond X-ray pulses both in soft and hard x-ray regions. To implement this source in a wide range of applications from time-domain X-ray diagnostics to the nuclear excitation it is extremely essential not only to understand plasma processes taking place but also to control plasma parameters in order to achieve the desired X-ray pulse characteristics.

In this paper we report on our recent progress in both experimental and theoretical investigation of interaction of superintense femtosecond laser pulses with nanostructured targets enabling plasma control in very efficient way.

In the first part we consider our results with freely suspended films a few tenths of nanometers in thick. Inhibition of thermal flux deep into the target provides mean thermal electron temperatures up to 1 keV. In the case of carbon film 25 nm in thick threefold increase in "water window" x-ray yield was measured. We also investigate the possibility to enhance hard x-ray production using metal (Ni, W) films.

In the second part we present results for cluster-like solid-state-density targets. This target type could be exemplified by highly porous semiconductors (Si, GaAs, etc.) having average density of 0.1+0.2 as compared to the solid, and consisting of chaotically arranged quantum wires. We discuss our comparative study of the yield of 2-nd harmonic, soft and hard x-rays, and hot ions from porous Si and crystalline one. We obtain that 2-nd harmonic signal drops down with average material density, soft x-ray yield keeps the same value, whereas hard x-ray output increases 3-30 times depending on quanta energy. Theoretical model of the laser plasma interaction in this case involves dumped thermal conduction, fast threads ablation accompanied by ion temperature increase due to ion-ion collisions, Coulomb explosion, hot electrons and ions production, etc. Other materials of the same type are also addressed.

This work was done under support from Russian Fund for Basic Research (grant #96-02-19146a) and Russian State Program "Fundamental Metrology".

9:15
FD3
(Invited)

ICONO'98
(XVI International Conference on Coherent and Nonlinear Optics)

Advanced photon sources and their applications

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Aiming at the realization of the advanced photon sources with ultra short pulse,ultra high peak power,ultra short wavelength ranging from extreme ultra violet to gamma ray region, and high coherence, and also the realization of advanced application of these sources, at first research and development of ultra high peak power laser have been achieved at first to drive an X-ray laser,laser induced particle accelerator, and quantum beam interaction between high density photons and high quality electron beam.

In the development of ultra short pulse laser,the target of this program is to get PW class high peak power based on chirped pulse compression using Ti:sapphire which is further supported by the new laser materials. The ultimate goal is the construction of table top laser system which is to be supported by the laser diode pumped solid state laser to drive a practical table top laser with ultra high peak power. A 100TW laser system with a pulse width of below 20fs at 10Hz repetition rate has been developed using Ti:sapphire laser crystals. A 105W average power green laser at the repetition rate of 170Hz specially designed for Ti:sapphire laser has been demonstrated together with the adaptive optical system for compensating the wave front distortion of the laser beam in the all all solid state laser system with high thermal load.

For the development of X-ray radiation and X-ray lasers,ultra high peak power laser is now being used to realize the hard energy X-ray radiation based on the interaction between highly dense laser photons and matter for the purpose of variety of application fields such as ultra fine X-ray imaging and X-ray lithography at high brilliance, as well as the scientific experiments in ultra high field physics. X-ray laser oscillation process is being studied based on the plasma process and atomic process for the sake of realization of a table top X-ray laser.

Application of ultra short pulse laser and X-ray sources are developed in chemistry and physics. Especially in the ultra fast chemistry, femto second ablation mechanism is observed by the ultra fast ultra violet laser aiming at the chemical control in the very initial process,and the new chemical reaction by the ultra high density radical reaction in the polymerization.

To carry out the basic study on the laser acceleration process, laser wake field in the laser induced plasma is intensively investigated using interferometric method parallel to the development of highly compressed bunched electron beams.

In the gamma ray emission and nuclear spectroscopy,advanced technology such as superconducting RF accelerator and photo cathode gun for high quality electron beam is now being used for the development of ultra short wavelength light source with high coherence based on the higher harmonics generation and coherent bremsstrahlung with super lattice.

9:45
FD4

Generation of up to 40 Order Harmonics from Solid Targets by Femtosecond Laser Pulses

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In recent years, harmonic generation in noble gases by ultrashort laser pulses [1] has attracted great interest because of the opportunity to produce harmonics of extremely high orders and ultrashort pulses of very short wavelengths [2, 3]. Much higher conversion efficiencies than in gases can be expected from harmonic generation of laser light upon reflection from the boundary of an overdense plasma [4, 5]. In this case harmonic radiation is emitted in the specular direction. Very steep plasma density gradients suitable for harmonic generation can be obtained when a clean femtosecond pulses interacts with the surface of a solid. This paper describes new results on the observation of high order harmonics in such a scheme.

Laser pulses from a titanium sapphire laser system of 35 fs duration and an energy up to 50 mJ were focused on the surface of glass or aluminum (thin film) target with an off-axis parabolic mirror (f/6). The beam was p-polarised, and the angle of incidence was 68°. The third-harmonic autocorrelation measurements demonstrated an intensity drop of 10^6 in about 1 ps. The pump intensity in the focal plane was estimated to be 5×10^{17} W/cm^2. Compared with our previous experiments [6] the use of shorter pulses and an improved detection system permitted the observation of harmonics up to about 40th order. Measurements of the spatial distribution of the harmonics demonstrated a divergence smaller than that of the fundamental beam.

[1] A. L'Huillier and P. Balcou, Phys. Rev. Lett. **70**, 774 (1993).
[2] Ch. Spielmann, N.H. Burnett, S. Sartania et al., Science **278**, 661 (1997).
[3] Z. Chang, A. Rundquist, H. Wang et al., Phys. Rev. Lett. **79**, 2967 (1997).
[4] R. Lichters, J. Meyer-ter-Vehn, and A. Pukhov, Phys. Plasmas **3**, 3425 (1996).
[5] D. von der Linde and K. Rzazewski, Appl. Phys. B **63**, 499 (1996).
[6] D. von der Linde, T. Engers, G. Jenke et al., Phys. Rev. A **52**, R25 (1995).

10:00
FD5

Ultrahigh contrast subpicosecond laser-solid interaction

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We present the first laser-solid experiments carried out using a new ultrahigh contrast subpicosecond laser.

High-energy, ultrahigh contrast subpicosecond laser pulses at the wavelength of 1.056 mkm have been generated by amplification of a Raman-shifted compressed ruby laser pulse in Nd:glass amplifiers. The measured ratio of 0.8ps pulse brightness to ASE one exceeded 10^{12}. Moreover the computer simulations of this laser predict an extremely steep leading edge of the laser pulse: the intensity rises by 12 orders of magnitude in 1 ps. Such laser pulse is very favourable to avoid the plasma formation by the laser prepulse and provide the energy deposition in solid density plasma at high laser intensity.

The electron temperature, harmonic generation and plasma reflectivity have been measured at laser intensities of up to 10^{16} W/cm^2. The following experimental results are presented and discussed:

1. The peak electron temperature increases linearly with the radiation intensity, reaching 1 keV at 2.3×10^{16} W/cm^2. The temperature is independent on the polarisation of the optical field incident obliquely on the target.

2. The 2nd and 3rd harmonic generation efficienses are strongly dependent on the laser beam polarisation. The ratio of harmonic energy at p-polarisation to s-polarisation one is about 10 for second harmonic and more than 10^3 for third harmonic. A power-fit law to the harmonic energy is $E_{2w} \sim E_{3w} \sim I_w^{1.2}$ at p-polarisation of the laser pulse and $E_{2w} \sim I^{1.8}$ at s-polarisation. The energy conversion efficiency at 10^{16} W/cm^2 of the fundamental beam is 1.5×10^{-5} (second harmonic) and 0.8×10^{-5} (third harmonic).

3. The reflectivity of Au target at the incidence angle of laser beam of 45^0 is 30 % at p-polarisation and 50 % at s-polarisation. The laser intensity was from 10^{15} to 10^{16} W/cm^2.

The observed effects are explained by interaction of laser radiation with an overdense sharp-edged plasma produced by the ultrahigh contrast laser pulse.

10:15
FD6

Investigations of Optically Field Ionized Plasmas for Soft X-Ray Laser Applications

B.N. Chichkov*, A. Egbert, D. Simanovskii**, and B. Wellegehausen

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** P.N. Lebedev Physics Institute, Leninsky pr. 53, Moscow, Russia*
*** A.F. Ioffe Institute of Physics and Technology, Polytehnicheskaya 26, St. Peterburg, Russia*

Summary

With ultrashort pulse laser systems a strongly nonequilibrium plasma can be created by optical field ionization (OFI) of a gaseous medium in an intense laser field. Investigations of OFI plasmas are important for soft x-ray laser applications. We present results of time-resolved studies of helium and oxygen plasmas produced by focusing of 150 fs Ti:sapphire laser pulses into He and O_2 gas jets. Linearly and circularly polarized laser pulses at 800 nm and at the second harmonic (400 nm) with energies of 100 mJ or 60 mJ are used.

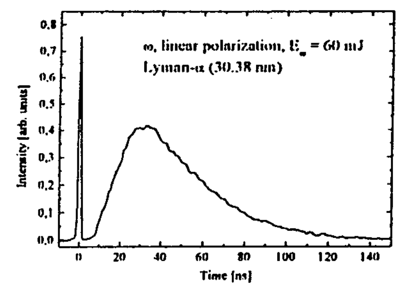

Fig. 1: Temporal evolution of the He$^+$ Lyman-α emission

A typical temporal evolution of the Lyman-α emission in He$^+$ (λ = 30.38 nm) is shown in Fig. 1. The observed fast and slow He$^+$ line emission components originate due to electron impact excitation and three-body recombination, respectively. By varying the laser frequency and polarization, the intensities and the temporal characteristic of the fast and slow line emission components can be manipulated. Amplification on the Balmer-α transition (λ = 164 nm) of He$^+$ ions has been demonstrated for the first time. Analogous investigations have been performed with OFI oxygen plasmas, where soft x-ray amplification in OIII ions (λ = 37.4 nm) has been previously observed [1]. We demonstrate the importance of several experimental conditions and present new results supporting our previous observations.

[1] B. N. Chichkov, A. Egbert, H. Eichmann, C. Momma, S. Nolte, B. Wellegehausen, Phys. Rev. A 52, 1629 (1995)

11:15-13:30 **GREEN HALL**

FE - Coherent Optics and Laser Physics: Moving Frontiers in Information Technologies IV

Presider: *V.Ya. Panchenko, Sci. Res. Ctr. For Technol. Lasers, Russia*

11:15
FE1
(Invited)

LASER INFORMATION TECHNOLOGIES:
BASIC ACHIEVEMENTS AND DEVELOPMENT PERSPECTIVES

Peter E. Tverdokhleb

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Contemporary trends in developing a new generation of information technologies are considered, these are based on laser methods for modification of physical properties of materials (media or substances) in micro- and nano-regions. The technologies are used for high precision image writing (photomasks, hardcopies), for super compact data storage, for data displaying, for high precision measurements, as well as for material processing (including living tissues), and so on. Basic light-induced thermo- and photochemical reactions., new requirements for worthwhile materials and light sources are discussed. A special attention is paid to three-dimensional (3D) laser technologies that are able to modify media properties not only on the surface, but inside the media volume, above make it possible to synthesize (generate, create) three-dimensional "products" directly within a material (media). Distinctive examples are- the following, 3-D media for data storage, visualized 3-D images, layer-by-layer synthesized models, polychroinatic diffractional gratings with a deep geometry relief (phase profile) and so on.

11:45
FE2
(Invited)

THREE-DIMENSIONAL FLUORESCENT OPTICAL DATA STORAGE. THE CURRENT STATE OF ART AND TRENDS OF DEVELOPMENT.

S.A.Magnitskii

International Laser Center of Moscow State University
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It is generally recognized that, due to the possibility of storing the data in three dimensions, 3D optical data storage (ODS) offers considerable scope for increasing the data storage capacity up to 1 TB/cm^3. Despite the fluorescent ODS has so far received much less attention than holographic memory, it probably can be the first that will be realized in commercial products. It is important that all 3 types of ODS (ROM - read only memory, WORM - write once read many and WRE - write-read-errase memories) may be realized in fluorescent variant.

The current state of art and prospects of creating digital 3D optical-memory systems based on fluorescent reading are analyzed.

The table-top prototype developed for implementation of principles of single-beam two-photon sequential writing by the trains of femtosecond laser pulses, and fluorescent parallel readout of information is described.

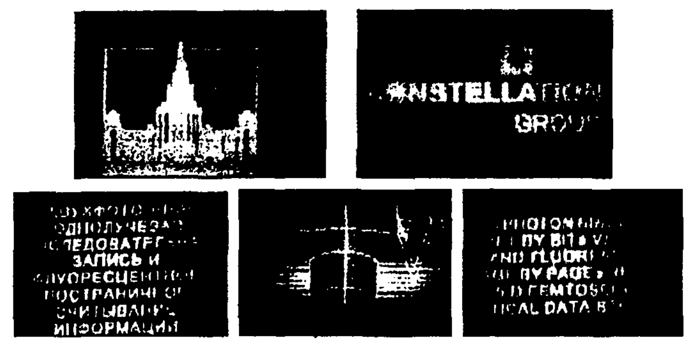

Fig.1. Fluorescent images obtained by sequential reading of pages from multilayer naphthacenepyridone polymeric matrix.

Characterization of the writing, reading and erasing processes in fluorescence 3D ODS is presented.

12:15
FE3

Optical studies of Mn:$YAlO_3$, promising material for holographic recording and optical data storage

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We have studied photoinduced absorption, associated with it refraction index change, and holographic grating recording in Mn doped yttrium orthoaluminate (Mn:$YAlO_3$.). We have shown Mn:$YAlO_3$ to be a promising material for optical storage and holography. In particular, we have found that:

(I) Under photoexcitation Mn^{4+} ions in as grown yellowish crystal disproportionate to Mn^{5+} and Mn^{3+}. Mn^{5+} ions are responsible for intense grayish-bluish coloration of exposed samples.

(II) Photoinduced color center formation in Mn:$YAlO_3$ (at 514.5 nm) is a two photon process. The rate of coloration and the rate of diffraction quadratically depend on (cw) excitation intensity.

(III) At room temperature photoinduced coloration and associated with it holographic grating can be stored in the crystal for more than one year. Increasing the temperature of the crystal strongly accelerates both photoinduced coloration and coloration erasing processes.

(IV) The diffraction efficiency of the grating recorded in the crystal is high. It exceeds 50% at the writing wavelength (514.5 nm) and 1-2% in infrared (800-930 nm).

(V) Strong energy exchange between two beams of equal intensities observed in the two wave mixing experiment suggests that holographic grating in Mn:$YAlO_3$ is recorded with 90 degree shift between interference pattern and refractive index grating. For realization of this mechanism doped crystal should be noncentrosymmetrical, in contrast with undoped $YAlO_3$ which is known to be centrosymmetrical. The possible reason for the symmetry change in Mn doped photoexposed crystal will be discussed at the conference.

12:30
FE4

PHOTOINDUCED GRATINGS IN SEMICONDUCTORS WITH METASTABLE DEFECTS

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We describe a family of reversible holographic storage materials which exploit the metastability of impurity defects known as DX centers in both typical semiconductors as well as the unconventional highly ionic semiconductor CdF_2. A local photorefractive effect in these crystals results from the photoinduced switching of the centers from their ground state to a metastable state in which free or weakly-bound electrons are released in the antinodes of the diffraction pattern. A refractive index shift of 10^{-4}-10^{-2} is achieved for absorbed fluence 10-300 mJ/cm^2 ensuring nearly 100% relative diffraction efficiency of the grating. These parameters are independent of exposing irradiance from 10^{-3} to 10^8 W/cm^2. The persistent nature of the grating is due to an energy barrier separating the metastable and ground states. The more ionic the crystal, the higher is this barrier. Depending on the DX material the long-term (years) persistence temperature T_p ranges from 50 K to 200 K, the latter temperature is achieved for CdF_2:Ga. The gratings decay with a characteristic time depending on the height of barrier separating metastable state from the ground state and vice versa, the temperature, and the center concentration. We describe properties of these media which determine two possible fields of their application. The first is the high-capacity storage for three-dimensional optical memory. The second application is as a dynamical phase-conjugate mirror for wave-front correction. Characteristics of DX materials related to these two areas are discussed.

12:45
FE5

LASER TECHNOLOGIES IN DIFFRACTIVE OPTICS

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Researches on fabrication of diffractive optical elements by laser beam direct writing were started in the middle of 1970s in the IA&E SB RAS. Circular laser writing systems have been designed and number of technologies for manufacturing of diffractive elements have been developed. The given paper presents the review of these works and latest results on diffractive optics fabrication.

Technologies for high performance DOE fabrication were the main fields of investigation. One step direct technologies are powerful instrument for diffractive optical elements fabrication. The thermochemical writing methods allow to simplify the technologies of mask production. The writing process is based on thermochemical changes in thin chromium and amorphous silicon films under laser radiation action. The main advantage is production of high quality binary diffractive structures without photoresists usage. Halftone method based on the technique of halftoning and incoherent spatial filtering combined with the lithographic process and gray tone method based on modification of surface layer of LDW glass were implemented and investigated. The DOEs with deep (up to 10 μm) continuous relief were fabricated using X-ray mask and X-ray radiation.

13:00
FE6

COHERENT ELECTROSTRICTIVE EFFECTS IN FIBERS

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Electrostriction is of prime importance in fiber transmissions, since it is the motor of the stimulated Mandels'tam-Brillouin backscattering (SBS), a major non-linear limitation to the power handling capacity of optical fibers. At low optical power, the so-called (forward) guided-acoustic-wave Brillouin scattering (GAWBS) [1,2] is a resonant noise considered as a serious hindrance for fibers quantum-optics experiments. In fiber optical transmissions, the slow relaxation of electrostrictive excitations is also responsible for the so-called long-range acoustic interaction (LRAI) between solitons [3].

The electrostrictive LRAI contribution to the nonlinear index is generally presented as a Kerr-like effect affecting only the phase of the signal; this model, based on a full analysis of the transverse acoustic modes of the fiber [3,4], is in good agreement with the measured values at moderate signal powers [5,6]. On the other hand, the usual treatment of GAWBS involves the intensity rather than the phase of the signal. Here, we propose an unified 1D description of both effects, where transverse resonances are described as a collection of damped oscillators coupled to the optical waves through electrostriction.

This model remains valid for high signal powers, and when the phases and amplitudes are coupled through another effect, such as sbs or dispersion. Indeed, strong GAWBS resonances are identified in the oscillatory transition region between the solitonic and "mirror" regimes of SBS resonators [7]. We will thus compare the experimental dynamics of a cw-pumped SBS fiber ring laser (λ = 514,5 nm) with numerical simulations of this coherent model, and discuss the possibility of SBS-induced *stimulated* GAWBS.

1. R.M. Shelby, M.D. Levenson and P.W. Bayer, Phys. Rev. B **31**, 5244 (1985).
2. A.J. Poustie, J. Opt. Soc. Am. B. **10**, 4, 691 (1993).
3. E.M. Dianov, A.V. Luchnikov, A.N. Pilipetskii and A.N. Starodumov, Opt. Lett. **15**, 6, 314 (1990).
4. A.A. Golovchenko and A.N. Pilipetskii , J. Lightwave Tech. **12**, 6, 1052 (1994).
5. E.L. Buckland and R.W. Boyd, Opt. Lett. **22**, 10, 676 (1997).
6. A. Fellegara, A. Melloni and M. Martinelli, Opt. Lett. **22**, 21, 1615 (1997).
7. E. Picholle and A. Picozzi, Opt. Comm. **135**, 327 (1997).

13:15
FE7

ASSOCIATIVE PROPERTIES OF THIN HOLOGRAMS AND MECHANISMS OF ASSOCIATIVITY

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The technique of phenomenological analysis of informational structure of correlation responses of thin holograms in matched filtering regime, which is compatible with neuron-network paradigm, is suggested. With its help on the basis of deriving informational components of those parts of correlation responses, which were previously interpreted as noise, it became possible to more fully describe associative reconstruction of information in the zeroth and minus second orders of diffraction of quadratic off-axis hologram.

Informational properties of thin referenseless hologram of mutually conjugated waves, registered with the help of phase-conjugate mirror, are theoretically investigated. It is suggested to use this hologram in systems of memory and associative reconstruction of information with high level of protection.

In the system, composed by linear off-axis hologram and linear phase-conjugate mirror the processes of repeat diffraction by hologram of components of scattered by it field, corresponding to different orders of diffraction, are considered. It is shown, that they lead to transformation of nonlinear on object field and reading- out fragment noise components (i.e. not interpreted as an image or a correlation peak) of field into informational ones (whole or fragmentary images). It is suggested to associatively read out information not in the traditionally used zeroth, but in the second, being formed at the repeat scattering by hologram, order of diffrac- tion, in which the reference wave as well as the noise, superimposed on it, reconstruct the whole object field.

11:15-13:45 **RED HALL**

FF - Biomedical Optics II

Presider: *J. Fujimoto, Massachusetts Inst. of Technology, USA*

11:15
FF1
(Invited)

Image acquisition: making ultra-thin endoscope of one multimode fiber

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Image transmission through a flexible optical device, i.e. through an endoscope, is in great demand in medicine and industry. Present optical endoscopes are made of rather thick (3-5 mm total diameter) bundles of about 10,000-100,000 fibers, each carrying the information about individual pixel of the image. This is to be contrasted to a multimode waveguide with about 10,000 modes at 100 times less cross-section, or at 10 times smaller diameter, and the potential number of pixels is just the number of transverse modes. Hence the problem of transmission and acquisition of images through one multimode fiber always was a challenge for optical community. Some attempts were made to transmit one-dimensional patterns [1], to use Optical Phase Conjugation [2], etc., but neither of those techniques promised the possibility of acquisition of two-dimensional images through one fiber: possibility that would withstand the bending of the endoscope.

We have recently proposed several methods of image acquisition with one multimode fiber [3]. One of them is to illuminate the object through a fiber by a prescribed set of patterns (either speckle-type, as in the method of Random Transverse Tomography, or a point-like, as in the Phase Conjugate Scanning method) and to photo-detect the total signal of light scattered by the object. Then the computational algorithms developed by us allow to reconstruct the image.

The main problem is to assure that the input-to-output field transmission function of the fiber is stable against bending and twisting, which are inevitable in most applications. We have suggested [3] and have demonstrated in a physical experiment [4] the ways to stabilize it, via pre-bending and controllable loosening of an auxiliary part of the fiber. The main idea behind this stabilization is that reasonably smooth bending and twisting do not mix the modes, but change adiabatically their phase velocities only. Therefore the control over the "integral of the bending" allows to keep the modal phase differences stable. Several other methods of quality beam transmission and image acquisition will be discussed as well, all of them based on this idea of adiabatic preservation of an individual mode. The work was partly supported by the US AFOSR grant F49620-95-1-0520.

1. A. A. Friesem, U. Levy, Y. Silberberg, Proc. IEEE, **71**, p.208, 1983.
2. A. Yariv, Appl. Phys. Lett., **28**, p.88, 1975; G. J. Dunning, R. C. Lind, Opt. Lett., **7**, p.558, 1982.
3. M. A. Bolshtyansky, B. Ya. Zel'dovich, Appl. Opt., **36**, p.3673, 1997; Opt. Eng. **35**, p. 769, 1996; Opt. Comm., **123**, p.629, 1996.
4. D. Z. Anderson, M. A. Bolshtyansky, B. Ya. Zel'dovich, "Stabilization of the speckle pattern of a multimode fiber undergoing bending", Opt. Lett. 1996, **21**, p.785, 1996.

11:45
FF2
(Invited)

Laser spectroscopic investigation of radical formation during laser tissue interaction

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Laser spectroscopic measurements are a very effective method for the on-line investigation of formation processes of harmful substances during laser treatment of tissue in medicine.

Specific small molecules, radicals, atoms and ions produced during laser application for cutting and evaporation of tissue characterise the kind of laser tissue interaction.

The molecule fragments in the ground or excited states have been detected in dependence on the applied medical laser system by spontaneous or laser induced fluorescence. In addition to the well-known CN, OH, CN, CH_2 and C_2 radicals also NH, SH and CS radicals were detected in the laser interaction zone by laser spectroscopic methods.

The chemical reaction processes in the laser tissue interaction zone can be changed significantly by the surrounding gas atmosphere. The analyses of the laser plume reflect clearly the interplay of complete and incomplete oxidation in dependence on different gas atmospheres in the reaction zone. An increasing oxygen content in the surrounding atmosphere reduces the amount of harmful substances in the laser plume, while the formation of the toxic compound increases in the so-called protective gases like nitrogen and helium.

The application of pure oxygen and oxygen enriched gases is limited in laser medicine because of safety regulations. The production of toxic and carcinogenic substances was also reduced significantly without deteriorating the cutting or evaporation effect by application of a water spray concentrated into the interaction zone. In the present paper it will be shown that the content of water in the laser tissue interaction zone has a significant influence on the formation of the organic substances in the laser plume.

Therefore the influence of a water spray on the formation process of typical small molecules and atoms (OH, O, CN, CH, CH_2) was investigated by laser spectroscopic measurements and in the case of CO and CO_2 detection by gas chromatographic measurements. Comparing the results of gas chromatographic and mass spectrometric measurements with laser spectroscopic investigations it becomes clear that the relative fluorescence intensity of the CN, CH and CH_2 radicals corresponds to the qualitative amount of harmful substances produced in the laser plume

The cutting efficiency in the case of water spray application is unchanged in comparison to the treatment without water spray but the quality can be improved as histological investigations demonstrate. A further increase of water outside the optimum leads to a lost of cutting effectiveness.

The presented method is suitable to improve the cutting quality and reduce the production of toxic and carcinogenic substances in the laser plume.

12:15
FF3
(Invited)

COHERENT AND POLARIZED LIGHT TRANSPORT IN TISSUES AND TISSUE-LIKE PHANTOMS WITH CONTROLLED SCATTERING PROPERTIES

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It is well known that the turbidity of a dispersive physical system can be effectively controlled using an immersion effect (matching of refractive indices of scatterers and base material). Control of the optical properties of living tissues is important for many applications in laser medicine including coherent and polarization tomography and transscleral or transskin coagulation. The present paper describes mainly the experimental results of coherent, low-coherent and non-coherent polarized light propagation within tissues and tissue-like phantoms.

Measurements were done *in vitro* for the human eye scleral samples and human skin strippings. For the scattering properties control of scleral samples various osmotically active solutions like trazograph, verografin, glucose and polyethylene glycol were used. Thin epidermal strippings were optically cleared using water, glycerol, DMSO solution and some other immersing liquids.

The matter diffusion equation and irreversible thermodynamics approach were used to analyze the dynamics of solutions components diffusion within tissue. On the base of collimated light beam propagation through the tissue sample under control the estimation of diffusion coefficients for various chemicals including glucose and trazograph was done.

The speckle-correlometry and spectral polarimetric measurements were undertaken for description of tissue or tissue-like phantoms structure changes in a process of tissues optical clearing using immersion or due to absorption and scattering coefficients variation.

12:45
FF4

TIME-RESOLVED OPTO-ACOUSTICS MONITORING OF TISSUE *IN VIVO*

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Time-resolved laser opto-acoustic monitoring of light distribution in tissue *in vivo* is discussed. Detection of absolute amplitude of the acoustic transient, excited due to the absorption of sufficiently short laser pulse, enables one to investigate both light extinction and absorption [1-3]. The temporal course of the excited acoustic transient follows the distribution of absorbed specific laser energy. In the case of tissue in visible and near IR light scattering coefficient is much greater than absorption one. So, scattering determines light intensity distribution in tissue and the optoacoustic sources are the product of light absorption coefficient and light intensity distribution.

The background of laser excitation and time-resolved detection of acoustic transients is discussed. The reconstruction of light absorption in the cases of macro-inhomogeneous absorbing medium, absorbing medium with absorbing particles, turbid absorbing medium is discussed. In the last case light extinction and light absorption coefficients are determined separately.

The methods mentioned above are examined experimentally for model media. The light absorption and light extinction at λ=0.53 µm and 1.06 µm were monitoried inside hand skin, melanomas, blood vessels in hand *in vivo.* As an example in the hand skin λ=0.53 µm the extinction coefficient μ_{eff}=32±5 cm^{-1} and μ_a=2.7±0.5 cm^{-1}. The blood vessel at the depth 0.3 mm was evidently detected.

REFERENCES

1. A.A.Karabutov, V.S.Letokhov, N.B.Podymova. Appl.Phys.B, 1996, 61, 1105.
2. A.Oraevsky, R.Esenaliev, et.al. SPIE Proc. 1996, 2681, 288.

OPTICS OF BLOOD AND ITS COMPONENTS

13:00
FF5

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Major optical parameters of blood characterizing light absorption, scattering, and fluorescence are defined by its complex composition and variable structure both highly dependent on the dynamic status of blood, conditions of *in vivo* or *in vitro* measurements, and external factors. Physical properties of blood like micro- and macro-viscosity, elasticity, fluidity, structural stability, affinity to gases (mostly oxygen and carbon dioxide) determining its physiological transport functions, are related to the content, properties, and interaction of the blood formed elements (erythrocytes, platelets, lymphocytes) and of major proteins constituting the blood plasma. These highly depend upon the status of the organism and reflect many physiological dysfunctions. They can be measured by different optical and laser techniques, thus enabling least invasive and, sometimes, early diagnostics and efficient follow-up of therapeutical interventions and treatment.

For example *in vivo* transcutaneous measurements of wavelength-dependent light absorption by blood enables to estimate and monitor the amount of oxygen in tissue. Parameters of static and dynamic light scattering measured *in vitro* from samples of blood plasma enable to evaluate the immune status of the human organism and its status in respect to tumor, cardiac and other diseases. Measurement of the amount and of the kinetics of static light scattering as well as imaging of the diffraction patterns from suspensions of blood formed elements and/or from samples of whole blood *in vitro* enable to quantitatively estimate many hemorheological disorders. So do *in vivo* dynamic light scattering and, in particular, laser Doppler measurements of blood perfusion in tissues and of blood flow velocities in single vessels. Application of low-coherence-length and/or ultra-short-pulsed laser sources open here new possibilities for dynamic optical coherence tomography and imaging. NIR Raman scattering from tissues and from blood plasma samples is shown to be sensitive to low amounts of clinically important blood plasma analytes such as glucose, cholesterol, lactic acid, creatinine, etc. Certain alterations of relative intensities of RRS spectral lines from blood samples are characteristic for sepsis, cardiac and other pathologies. Intensity and kinetics of chemiluminescence in blood samples correlate with the activity of phagocytes from individuals undergoing stress and desease. Therefore such measurements are used for diagnostic purpuses.

Thus optics of blood and its components is becoming a highly important subject for further fundamental studies aimed at the assessment of the molecular and cellular origin of diseases, and for applied research aimed at design of new detection and measurement techniques to be used in more efficient optical diagnostic medical devices.

Generation of Shear Waves in Phantoms of Biological Tissues by Pulsed Laser Radiation

13:15
FF6

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Sound absorption in biological tissues results in generation of shear wave inside them. Observations of shear waves radiated from the focal region of a focused ultrasonic tone burst beam have been performed in our previous study. The purpose of this work is to present the results of shear wave excitation by means of single submicrosecond shock pulse.

Light of a powerful infrared Nd-glass laser (λ= 1.06 μm) was absorbed in optoacoustic cell. Duration of a laser pulse was about 30 ns (Fig. 1a, curve 1) and its energy was varied up to 3 J. The surface of absorbing liquid had a spherical form and therefore focused acoustic pulse was produced (Fig. 1a, curve 2). Acoustic pulse propagated in water and a shock front at its profile was developed due to nonlinear

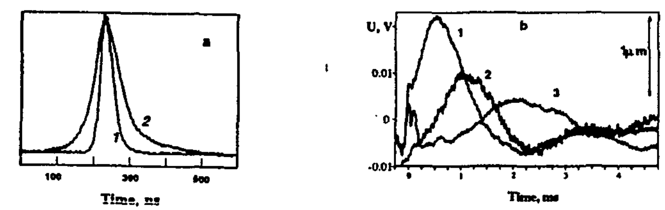

Figure 1.

effect. Shock front amplitude was about 300 bar. A transparent polymer block was positioned in the focal region of the acoustic beam. Shear waves in the block were registered optically.

Fig.1b presents shear waves profiles at the different distances between the observation point and the acoustical axis. The delay of the shear wave increases and its amplitude decreases with the transversal coordinate. The obtained shear wave speed (3±1 m/s) and peak displacements are in accordance with theoretical results. This work supported in part by CRDF (grant # RB2-131) and RFBR (grant # 97-02-16947).

13:30
FF7

COHERENT VERSUS NONCOHERENT OPTICAL PROBING OF DYNAMIC SHAPE FLUCTUATIONS IN RED BLOOD CELLS

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The shape of red blood cells (RBC) undergoes stochastic low-frequency bending oscillations named the flicker of RBC [1,2]. The flicker spectra are measured in the range 0.03-500 Hz using the frequency analysis of light intensity fluctuations in two regimes: backward laser light scattering from a cell, and phase contrast microscopy of a cell. The power spectrum curves are similar to those of $1/f$ noise, with an essential difference: their slope in the double logarithmic scale varies with the frequency, from $-(0.8\div1.2)$ below 10 Hz to $-(1.6\div2.4)$ above 50 Hz. The spectra measured with backward laser light scattering have systematically higher spectral amplitudes then measured in the phase contrast regime. The theory of RBC flicker is developed, based on the eigenmodes analysis of the bending oscillations of the cell envelope and the optical problem solution for the contribution from these oscillations to the total intensity of the scattered or transmitted light from the cell. The theory describes quantitatively the spectral curves, and relates their parameters to the main mechanical and shape parameters of RBC: bending modulus of cell membrane, viscosity coefficient of interior hemoglobin solution, and the thickness-diameter ratio of RBC. The difference in the spectra obtained by coherent and noncoherent optical probing of RBC flicker is explained partially by specific optical mechanisms of the registered signal formation. The remaining difference is possibly due to the quasielastic light scattering from the internal hemoglobin solution. No direct evidence is obtained for the contribution of the active processes in RBC to the flicker.

1. A.M. Beck, V.L. Kononenko. Proceedings of SPIE, 1991, Vol. 1403, pp. 384-386.
2. V.L. Kononenko. Proceedings of SPIE, 1994, Vol. 2082, pp. 236-247.

11:15-13:30 **BEIGE HALL**

FG - Interference Phenomena in Atomic Systems IV

Presider: *C.M. Bowden, U.S. Army RD&E Center, USA*

11:15
FG1
(Invited)

Paper is not available

11:45
FG2

Superradiant Generation of Femtosecond Pulses in Low-dimentional Semiconductor Heterostructures

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The challenge to obtain superradiant regime in lasers stems from the fact that superradiance provides the highest possible rate of stimulated radiative transitions and gives rise to generation of ultrashort powerful pulses. However, to achieve superradiant recombination of free electron-hole pairs in semiconductor lasers one has to overcome collisions that destroy the cooperative phase of oscillating dipole moments. The time T_2 of incoherent relaxation of polarization due to intraband scattering in semiconductors is as short as 0.1 ps, while the time of stimulated radiative transitions in direct band-gap materials is typically 0.1 ns. As a result, collective effects in the radiative electron-hole recombination are suppressed.

In this report we present theoretical analysis of single- and multimode recombination superradiance (superfluorescence) in quantum-well and quantum-dot heterostructures. We show that the conditions necessary for superradiance can be achieved, even at room temperature, in a heterostructure consisting of several $50-100$ Å quantum wells (or quantum dot layers) when the density of injected carriers exceeds $\sim 2 \times 10^{12}$ cm^{-2}. Numerical estimates are given for AlGaAs-GaAs structures; for other direct-gap semiconductors the results are similar. Moreover, the effect is possible in indirect materials, such as GeSi-Ge heterostructures, due to direct interband transitions in the Γ-valley of Ge.

In a standard treatment of collective spontaneous emission the incoherent pumping by ultrashort laser pulses is assumed. This strongly limits the range of possible practical applications. We have found and analyzed in detail the novel regime of superradiant generation in which a quasiperiodic sequence of femtosecond pulses is emitted under quasi-continuous optical or injection pumping. Such a regime can be realized when the usual stationary laser generation becomes unstable. The instability of cw generation occurs if two basic conditions are fulfilled: (1) very high pumping level, equivalent to the injection current density of order 10^4 A/cm^2; (2) a low-Q cavity of length $30-100$ μm that provides the photon lifetime shorter than T_2. According to our analytical and numerical calculations based on the semiconductor Maxwell-Bloch equations, the coherent optical pulses are expected to have duration $30-100$ fs, repetition rate $0.3-3$ THz, and peak power exceeding 1 W. The parameters of superradiant pulses are defined solely by the semiconductor active medium, the pumping power and the cavity parameters. There is no need in the mode locking, sophisticated fabrication technology and pulse processing technique that were used in experiments on subpicosecond pulse generation in usual diode lasers.

12:00
FG3

STRONG FIELD EFFECTS IN COHERENTLY COUPLED MULTIPLE RESONANT LEVEL SCHEMES: THEORY AND EXPERIMENT

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Coherent coupling processes in multilevel schemes have recently gained much attention in connection with attempts to manipulate the absorption and refraction, to enhance the nonlinear susceptibility, to realize lasers without inversion or to control optical processes in atomic or molecular physics.

Typically, when a number of laser fields interact with multiple level schemes, a variety of coherent coupling and interference effects occur, resulting in complex lineshapes and parameter dependencies.

Based on analytical formulas [1] for cw resonant or near resonant interactions in Λ - and V -type Raman schemes and double - Λ four level cycles, we discuss limiting cases and results of numerical Doppler integration for situations close to realized schemes in I_2 and Na_2 [2] or possible experiments. Specific examples for the manipulation of lineshapes in resonant Raman schemes including effects of power induced narrowing and elimination of Doppler broadening of the resonance, for the appearance of interference effects in fully resonant four- wave mixing in optically thick medium and for parametric gain in inhomogeneously broadened double-lambda schemes at bichromatic excitation will be given.

[1] A.K.Popov and S.G.Rautian, Proc. SPIE, v.**2797**, 49, (1996); A.K.Popov and S.A.Myslivets, Quantum Electronics, **27** (11), 1004 (1997).
[2] S.Babin et al, Opt. Lett. **21**, 1186 (1996); A.Apolonskii et al, Appl. Phys. **B 64**, 435 (1997).

12:15
FG4

Coherent Control of Photonic Band Gap

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There is a growing interest in the studies of the propagation of electromagnetic (EM) waves in periodic dielectric structures in the last decade. The interest is rigidly bind to an effect of photonic band gap appearance in these structures. It is well-known, that a stop band with zero density of states for EM modes propagating in given direction is forming in periodic dielectrical materials. This phenomenon has been demonstrated both theoretically and experimentally.

Usually properties of photonic materials are investigated for a weak EM fields neglecting nonlinear properties of crystals. It is important to determine new features of photonic nonlinear heterostructures, which can be useful in construction of physical devises (multi-layered dielectrical mirrors, filters), and can lead to a basis of new phenomena of classical and quantum electrodynamics.

In this paper we consider a coherent control of photonic band gap width by using a strong EM wave. The main idea is based on the fact, that the width of band gap depends on the intensity of EM field in the heterostructure with spatially modulated Kerr nonlinearity. This dependence appears due to spatial modulation of nonlinear index of refraction. Under some conditions it is possible to make this nonlinear structure transparent or reflecting for EM waves in chosen frequency band. The advantage of this approach is that this coherent control can be lossless.

For the model we use the heterostructure consisting of periodic one-dimensional array of linear and nonlinear layers. To fabricate nonlinear layer we propose to dope linear host material of one of these layers by Ξ-type tree-level atoms. We analyze the dispersion relations for waves in this nonlinear photonic material in the presence of strong field and show real possibility of photonic band gap guiding.

An application of proposed phenomena is Q-switching, filtering. It can be used for solution of other problems of EM wave parameters control. It is possible to investigate quantum properties of an atom, embedded in such heterostructure or solitary wave propagation in band gap under condition of amplitude modulated pump field, which can bear new interesting physical phenomena.

12:30
FG5

Atomic trapping in the excited state due to dynamically modified spontaneous relaxation

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It was shown recently that strong coherent driving can essentially modify relaxation processes in atomic system [1]. Taking into account this modification we analyze coherently driven three-level atomic system coupled to the vacuum reservoir. An intermediate atomic state is supposed to be close to either ground or upper atomic level. In both cases strong coherent field couples this intermediate state to one of atomic levels while another level remains uninvolved into dynamical interaction. Under conditions of fast relaxation at the low-frequency transition (between intermediate and nearby levels), strong driving and appropriate detuning we show that complete depopulation of the ground state and trapping of atoms in one of excited state is possible. Depending on detuning of driving field trapping can occur either into coherent superposition of driving levels or into one of atomic energy state, namely, into intermediate level (in case this level is situated close to ground state) or upper atomic level (in case intermediate level is situated close to upper state). The last situation corresponds to realization of full population inversion at the highest frequency atomic transition.

Dressed states basis allows for clear interpretation of this novel effect. In the limit of large driving field frequency detuning the interpretation via specific kind of Raman scattering in bare basis is also possible.

O.Kocharovskaya et.al., Phys.Rev.Lett., 74 (1995) 2451;
O.Kocharovskaya and Y.V. Radeonychev, Found. of Phys., 1997.

12:45
FG6

NONLINEAR SOLITARY WAVES IN MULTIDIMENSIONAL RESONANT PHOTONIC BANDGAP STRUCTURES

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Department of Applied Mathematics and Cybernetics, Moscow State University, Moscow 119899, Russia

The study of the nonlinear interactions in periodic structures has gain considerable interest in the past few years[1]. This is due to the finding of the novel kind of nonlinear solitary waves which are propagated at Bragg frequency within the linear forbidden gap band of the periodic medium. It has been shown that gap solitons and oscillating solitary waves exist in one-dimensional structures with resonant[2] and Kerr[3] nonlinearity. These waves are formed by two counterpropagating coupled Bragg modes. Here we investigate theoretically the dynamics of formation and propagation of nonlinear solitary waves in the general case of two-wave diffraction problem in 2D and 3D periodic resonant structures. The vector Bragg condition $\boldsymbol{k}_h = \boldsymbol{k}_0 + \boldsymbol{H}$ for the wave vectors $\boldsymbol{k}_0$ and $\boldsymbol{k}_h$ of the incident and diffracted waves and the reciprocal lattice vector $\boldsymbol{H}$ is to be setisfied in this problem.

The equations of two-wave nonlinear dynamic diffraction have been derived from the semiclassical Maxwell-Bloch equations describing the coherent light-matter interaction under Bragg condition. By means of analytical and numerical integration of the equations we investigated the process of formation and propagation of Bragg solitary waves for the different geometric schemes of diffraction. It has been shown that nonlinear solitary waves appear both in the case of Bragg geometry of diffraction like gap two-wave solitons and in the case of Laue geometry of diffraction like two-wave solitons of nonlinear Borrmann effect. The "Laue soliton" propagates in the direction of the normal to reciprocal lattice vector. The numerical simulation of diffraction process has given the possibility to study the wave dynamics in a finite medium under different boundary conditions.

This work was supported by the European Research Office of the US Army, contract No.68171-97-M-5698, and by the Russian Foundation for Basic Research, grant No.96-02-19285.

1. "Development and Applications of Photonic Band Gap Materials", ed. by C.M.Bowden, J.P.Dowling, and H.O.Everitt, special issue of J.Opt.Soc.Am. B, v.10, 279 (1993).
2. B. I. Mantsyzov, Phys.Rev. A 51, 4939 (1995).
3. C. M. de Sterke and J. E. Sipe, "Gap Solitons", in Progress in Optics, ed. by E.Wolf, v. XXXIII (1994).

13:00
FG7

Coherent Population Trapping in Optically Dense Sodium Vapour

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We report on both experimental and theoretical investigation of coherent population trapping (CPT) in optically thick sodium vapour. In our experiment, sodium atoms are excited on the D_1-line with laser radiation containing two components with a frequency difference close to that of the two hyperfine ground states of sodium. Such an excitation leads to trapping of atomic population in "dark" superpositional states. This reduces dramatically an absorption of the light, the effect which is referred to as electromagnetically induced transparency (EIT). Special attention is paid to the influence of the hyperfine and Zeeman structure of Na atoms on EIT. Apart from the Λ systems that allow preparation of CPT, there are transitions that do not, and there could be ground state sublevels that are not excited at all. In such a case, the laser polarizations and external magnetic fields play very important role. We analyze this complicated situation with the help of a model of four-level atom. The behaviour of EIT with respect to laser frequencies and intensities, magnetic field, and temperature of the vapour is investigated theoretically (with this simple model) and experimentally. A frequency transparency window δ_{EIT} is measured to have a subnatural width, which is a clear indication of CPT. The width δ_{EIT} decreases linearly with decreasing input laser intensity. The minimum intensity necessary for the observation of EIT is determined by the residual magnetic field. Measurements taken at different cell temperatures correspond to different saturated Na vapour densities and therefore to different optical lengths. The transmitted intensity at two-photon resonance decreases linearly and the transparency window δ_{EIT} decreases exponentially with the optical length. The observed behaviour agrees well with our theoretical considerations.

This work is supported by the Austrian Science Foundation under project No. S 6508.

13:15
FG8

Coherent Amplification and Generation in Optically Dense Resonant Media without the Population Inversion

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Russian Center of Laser Physics,=20
St.-Petersburg State University

In contrast to the well-known Dicke superfluorescence in amplifying media analogous phenomena in passive media have been studied to a lesser extent. Meanwhile, the possibility of of field oscillations at a cooperative frequency in a cavity filled with a passive substance was already being discussed in early works on interaction of coherent radiation and matter. In these works a fundamental results was obtained, according to which the cooperative frequency emerges as one of the most important characteristic of the interaction between electromagnetic field and the ensemble of two-level atoms, as a frequency of the energy exchange between the field and matter. This circumstance is essential at least from the point of view of designing lasers and laser systems with fairly unusual properties as far as spectral and temporal characteristics are concerned. In the report we discussed the next problems. In section 1, one of the most interesting problem of quantum electronics is considered, namely, the possibility of the parametrical excitation the cooperative phenomena at intracavity laser pumping of substance. In section 2 results relevant to the study of the cooperative radiation dynamics near a phase- -conjugating mirror are reported. Section 3 contains information related to experimental and theoretical investigations of the so-called cooperative mechanism of energy exchange between copropagating waves in optically dense resonant extended media without
population inversion. In a brief conclusion we discuss some relations between our results and QED of the resonator.

11:15-13:30 **BLUE HALL**

FH - Interaction of Superstrong Laser Fields with Matter: Nonlinear Optics and High-Field Physics VIII

Presider: *D. Von der Linde, Univ. of Essen, Germany*

11:15
FH1
(Invited)

NUCLEAR EXCITATION IN HOT DENSE PALSMAS

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Increasing interest to the problem of nuclear transitions excitation in laser plasma is due to the wide area of possible applications including spectroscopy of low lying isomer levels, Γ-lasing, and plasma diagnostics. Dense hot plasma, formed under interaction of superintense laser pulse with solid target, brings up new promising perspectives in this direction [1,2]. From one hand near solid state isomers density leads to an increase in total yield of excited isomers. From the other hand, extremely high, up to 10^{25} cm^{-3} density of thermal electrons with mean temperature up to 1 keV enhances the efficiency of Coulomb and inverse internal conversion excitation channels, and provides generation of keV x-rays capable for isomer photoexcitation.

In this paper we report on theoretical as well as first experimental results on the nuclear excitation in femtosecond laser plasma under "moderate" intensities of 10^{16}-10^{17} W/cm^2. We discuss efficiency of different mechanisms of nuclear excitation and relaxation in hot dense plasma for various isotopes with first excited levels below 15 keV. For stable ^{201}Hg isotope with 1.556 keV first excited level we estimate excitation efficiency as 10^{-7} for our experimental conditions, with dominant relaxation through internal conversion to $4S_{1/2}$ core and subsequent Koster-Kronig process. For $HgCd_{0.1}Te$ target we measured the flux of x-rays resonant with respect to Doppler broadened nuclear level as 10^7 photons/eV·sr per 10 mJ laser pulse. A set of other isotopes (both stable and unstable) with first excited level below 15 keV is discussed. Progress in elaborating of experimental schemes for the nuclear isomer excitation in hot dense plasma are also addressed.

This work was supported by Russian Foundation for Basic Research (grant #97-02-17013a).

1. A.V.Andreev, V.M.Gordienko, A.M.Dykhne, A.B.Savel'ev, E.V.Tkalya, JETP Lett., 66(5) 312 (1997).
2. A.V.Andreev, R.V.Volkov, V.M.Gordienko, P.M.Mikheev, A.B.Savel'ev, Izvestia RAN, ser.Phys., 62(2) 254 (1998).

11:45
FH2
(Invited)

EXPERIMENTAL APPROACH TO LASER-DRIVEN MONOCHROMATIC ELECTRON ACCELERATORS

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A brief overview of laser acceleration techniques and a comparative analysis between picosecond terawatt (ps-TW) CO2 lasers and T3 solid-state lasers for prospective high energy physics applications is presented. Special attention is given to two laser acceleration investigations: a staged electron laser accelerator (STELLA) experiment, which is being conducted at the Brookhaven National Laboratory Accelerator Test Facility (ATF), and a laser wakefield accelerator (LWFA), where ps-TW CO2 lasers may offer important advantages.

In the STELLA experiment, a small portion of the CO2 laser beam is used to generate electron microbunches via an inverse free electron laser (IFEL) process inside a wiggler. Separated by the laser wavelength, the microbunches acquire near monochromatic energy gain in an inverse Cerenkov acceleration (ICA) stage, which uses most of the CO2 laser beam. This approach strongly favors long-wavelength laser radiation. We describe the STELLA experiment set-up and computer predictions for a 150-MeV/m electron a cceleration attainable with the first ps-TW CO2 laser, PITER I, being commissioned at the ATF.

For processes based on electron quiver motion, like LWFA, the advantage of CO2 lasers over solid state lasers is primarily due to a gain of two orders of magnitude in the ponderomotive potential. The dependencies of the LWFA performance upon laser wavelength, power, and pulse duration are discussed and applied to optimization of plasma-channel LWFA operating in a linear regime.

Electron beam energy spread, emittance, and luminosity tend to improve with longer laser wavelength. These considerations, supported by quantitative examples, favor picosecond CO2 laser as the optimum choice for future advanced accelerator projects.

12:15
FH3
(Invited)

Interaction mechanisms of ultrahigh-power subpicosecond laser pulses with transparent solids

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Intensity range, where ultrahigh-power laser radiation - transparent solids interaction can be investigated, limited by damage processes. On this reason a search of ways overcoming this problem is of principal importance for ultrahigh-power laser-solids interaction studies. At the same time recent advances in developing ultrashort laser pulse generation techniques open new perspectives in this direction of laser physics.

Our theoretical studies have shown, that the fulfillment of some conditions is required for a mechanical damage in transparent solids under laser radiation which can not be realized in ultrashort pulse interaction range. An example of this is a surface ablation process, intensively studied at a present time, which is realized without the crack formation in the femtosecond pulsewidth range.

In this paper we analyze the laser-induced mechanical damage processes in transparent solids and formulate conditions at which they are not possible. Different laser-solids interaction mechanisms, both intrinsic and extrinsic ones, for ultrashort laser pulses are considered, and conditions at which a laser-induced breakdown without the crack formation can be observed in both a bulk and a surface of optical materials.

Theoretical results will be compared with recent experimental data on ultrashort laser pulse interaction with transparent solids.

12:45
FH4

MODELING THE ABLATION OF METALS BY HIGH-POWER LASER RADIATION

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Abstract

Metal ablation under the action of ultrashort laser pulses is studied numerically and analytically within a wide range of laser fluences (1-10^4 J/cm^2) and pulse durations (0.1-10^4 ps). The physical model used in the computer code is based on the two-temperature hydrodynamic equations, and takes into account the ponderomotive forces, the electron and ion heat conduction, and the ion viscosity. The model involves a description of the phase transition "condensed matter-vapor". For this purpose the phase equilibrium curve in the plane (p_i, T_i) is constructed, where p_i and T_i are the ion pressure and temperature, respectively.

In case of long laser pulses, the evaporation occurs in a hydrodynamic regime. In this regime the ablation front propagates faster than the heat conduction wave, and this makes the heat conduction ineffective as an energy transport mechanism. The laser radiation is absorbed in the subcritical region, and drives directly the ablation wave. The ablation in the hydrodynamic regime has a stationary character, and its duration is determined by the duration of the laser pulse.

In case of short laser pulses the thermal regime of ablation is realized at low fluences, and is transformed into the regime of ablation by a shock wave with increasing fluence. This happens when the pressure in the material heated during the thermal ablation stage becomes high enough to generate a strong shock wave ($t \approx \tau_h > \tau_p$, where τ_p is the pulse duration and τ_h is the typical time of hydrodynamic rarefaction of the heated material). The energy stored in he shock wave is released in the ablation process. The material behind the front of the shock wave (moving into the target) is in the vapor phase. The front of the shock wave coincides with the front of the ablation (rarefaction) wave, and the velocities of these waves are equal to each other. In the thermal regime the ablation ceases at the moment $t = \tau_h$. The ablation in the shock wave regime continues for some time (as long as the pressure at the shock wave front remains higher than a certain critical value). Later the shock wave becomes weak, and a detachment of the shock wave front from the phase transition boundary (which is now motionless) occurs.

Analytical models for thermal and shock-wave ablation regime description are proposed.

13:15
FH5

ABLATION OF MATERIALS BY FEMTO, PICO AND NANOSECOND LASER PULSES: A COMPARABLE STUDY

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The samples of stainless steel, ceramics and CVD diamond were irradiated in air at wavelengths of 532(539) and 266(270) nm. Pulses with 220fs and 0,9ps were generated by Nd:glass picosecond laser TWINKLE (Light Conversion Ltd.), for the experiments with 220ps and 7ns pulses Nd:YAP laser was used. Ablation rate was measured at pulsed fluence E=1-400 J/cm^2. Morphology of the craters was analized with optical and scanning electron microscope.

Femtosecond pulses showed no advantage in ablation rates for shallow craters and equal fluences. In deep holy drilling (aspect ratio 5-10) growth of ablation rate for shorter pulses was found. No evidence of non-thermal material heating and removal effects was obtained. These and some other observed effects are related to formation of plasma in material vapour and surrounding gas. During laser action such a plasma at high intensities strongly absorbs radiation and shields the target surface. After laser pulse termination long living plasma can transfer large part of its energy to the surface and cause its additional heating and ablation.

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